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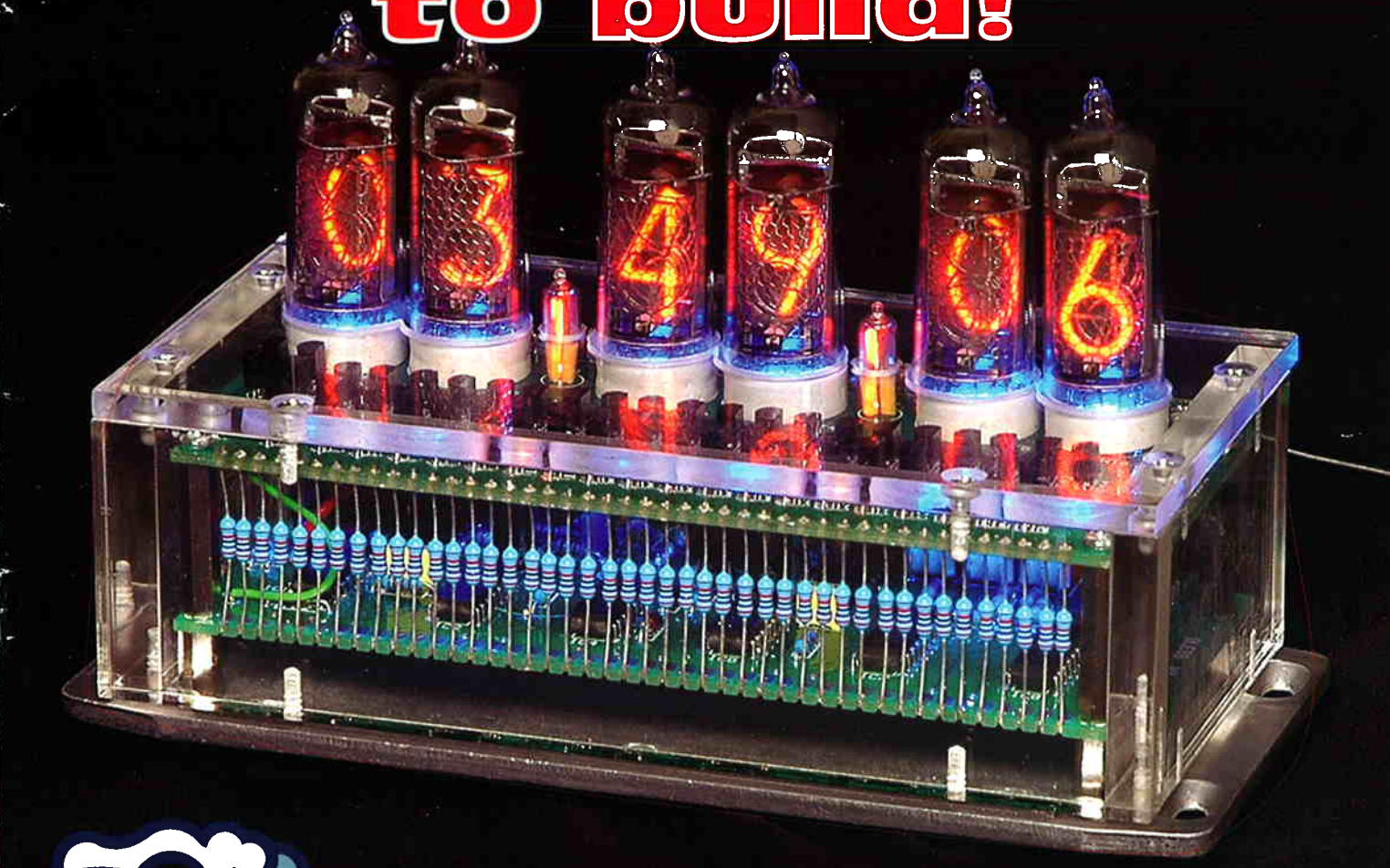
Retro NIXIE CLOCK to build!



ENERGY FEATURE: Saving the planet can also save you $$$$!

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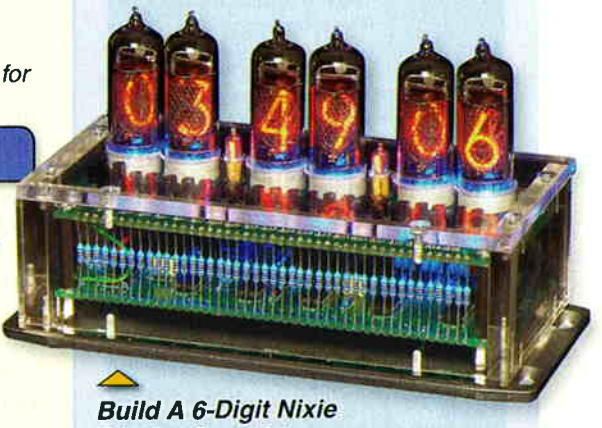

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Publisher's Letter

Energy saving on a large scale is possible

Last month's editorial and this month's feature on saving energy are just a small indication of the potential for energy conservation that will be employed over the next few years to cut back on greenhouse gas emissions. Indeed, it would not surprise us if western nations easily cut back their emissions by 40 or 50% over the next couple of decades. This is likely to happen regardless of edicts from governments and will be largely the result of rising energy prices, particularly those associated with oil and coal. Oil prices will naturally go up as the price to get it out of the ground goes up, in response to increasing demand from the Asian powerhouses, China and India.

One does not have to be an oracle to foresee this process unfolding, as there is a very strong precedent – the 1970s oil price shock. This sudden step increase in oil prices, due to action by OPEC, was severe enough to bring on a recession in a number of western countries but also resulted in the breaking of the nexus between GDP and oil consumption. Prior to the oil price jump, countries' GDP (gross domestic product) and oil consumption had marched ever upwards in lock step but once the relationship was broken, many countries' GDPs continued to increase without further direct proportional increase in oil consumption. Now we are going to have a more drastic appraisal of energy use and this will be a good thing, regardless of whether you believe the forecasts about global warming or not.

So in effect, governments do not have to force their nations' economies into saving energy and greenhouse emissions by enacting straitjacket regulations; just let the marketplace do it. For example, people will finally conclude that lumbering 4WD vehicles are a silly idea and decide on smaller, more economical vehicles. Many people will also decide that they don't need two or more vehicles when one will suffice. And once they become fully aware of how wasteful their home appliances are, they will replace them or change the way they use them. For its part, industry and commerce will rapidly change their practices to reduce energy use, no matter how "world's best practice" efficient they might previously have claimed to have been.

From our perspective, energy conservation is good because it does just that – it conserves valuable resources. It stops waste. It also reduces pollution and that must ultimately improve the quality of life for millions of people, particularly those living in the cities.

It will be very interesting to see just how all this pans out. Where will the biggest energy savings be made? In mining and industrial production? Transportation? Agriculture? The last one is going to be really interesting because we think the predicted large-scale conversion of crop lands to produce ethanol cannot last for long – it will ultimately make food much more expensive. Not only that, since large-scale agriculture requires such large energy inputs in the form of fuel, fertiliser and pesticides, such factors could rapidly make crops intended for ethanol conversion uneconomic.

On the road, we think that electric vehicles will finally become commuters' first choice; it is far more efficient to generate the required electricity in large power stations than it is to use petrol or diesel fuel in millions of cars. In the home, natural gas is likely to be preferred for space and water heating, as it is far more efficient to burn gas to directly heat water than to rely on large power stations. Ultimately, energy cost will directly affect prices and people will make the logical decisions.

Leo Simpson

MAILBAG

Letters and emails should contain complete name, address and daytime phone number. Letters to the Editor are submitted on the condition that Silicon Chip Publications Pty Ltd may edit and has the right to reproduce in electronic form and communicate these letters. This also applies to submissions to "Ask Silicon Chip" and "Circuit Notebook".

Incandescent bulbs cause more mercury pollution than CFLs

I found this interesting document that claims that incandescent bulbs are responsible for more mercury than CFLs. It was in a US Environmental Protection Agency fact sheet at:
http://www.nema.org/lamprecycle/epafactsheet-cfl.pdf

"Ironically, CFLs present an opportunity to prevent mercury from entering our air, where it most affects our health. The highest source of mercury in our air comes from burning fossil fuels such as coal, the most common fuel used in the US to produce electricity. A CFL uses 75% less energy than an incandescent light bulb and lasts at least six times longer. A power plant will emit 10mg of mercury to produce the electricity to run an incandescent bulb compared to only 2.4mg of mercury to run a CFL for the same time".

Franc Zabkar,
Barrack Heights, NSW.

Comment: we think the US EPA is drawing a pretty long bow by referring to mercury pollution via coal burning emissions. In any case, as inferred in the Publishers' Letter in the April 2007 issue, we do not think the banning of CFLs will result in much reduction, if any, of carbon (and related) emissions.

CFL article was alarmist

I was interested to read your article on CFLs in the April 2007 issue. I am running on solar power and have used CFLs virtually exclusively for about 12 years so I can make a few comments.

I think your article is a bit alarmist. First of all, the life of CFLs is highly variable. Some of mine have lasted in excess of 12 years and I have only replaced one or two because of decreased output. Almost all replacements have been from sudden failure, usually without warning, at switch on. One failed explosively; apparently a capacitor in the works. I have had no problems with using CFLs in sealed fittings – all my outside lights for example are in 7-inch spheres.

While the RFI from CFLs can be heard by tuning off-station on the AM or SW bands and moving the radio close to a bulb, it is less than the hash from the main inverters supplying the house and markedly less than the interference from my PC. I have never encountered any remote control problems that could be attributed to them.

As far as vibration goes, I have been using them in lead lamps in the workshop for years, one of their main advantages being they don't fail if you bump or drop them.

Your display of CFLs for comparison with incandescent lamps is clearly prejudiced – for a start, all the ones shown would have to be described as obsolescent types. The base containing the electronics today is typically half the size of that portrayed – 42 x 27mm compared to 50 x 45mm (measured from ones to hand). The variety of types in your supermarket is already much greater than the ones you show – the ones in my pantry include reflector globes, "candle" types and "Decor" spherical bulbs.

Bases available include all the ones shown in your display of incandescent bulbs except the low-voltage halogen. The form factor of CFLs today can be

No more class-A amplifiers please!

Can you please produce a project that is a different kind of amplifier than the stock standard class-A, B and AB designs (for example, your current 20W class-A amplifier)? Almost every amplifier design by your magazine is textbook stuff and to me is very boring.

How about something more technical that is not written in detail in most texts, like class-D which uses pulse width modulation? There are quite a few manufacturers making class-D ICs.

Besides class-D, I have read application notes that suggest using accelerometers mounted to the speaker drum to provide feedback of the speaker's motion, which could possibly be used to produce very low frequency amplification. I would like to see an all-digital amplifier that takes MP3 data source in digital format and drives the speaker using pulse code modulation.

Having said all that, I suppose a class-A amplifier is still good introduction to electronics for students and hobbyists and the latest design has very low distortion.

J. Dickson,
via email.

Comment: we have spent quite a bit of development time with class-D chips but we found them unreliable – they kept blowing up. Also their distortion is nowhere near as good as a good class-B design, let alone class-A. We are aware that there are many consumer products now with class-D amplifiers but their sound quality generally leaves a great deal to be desired.

The idea of using accelerometers to provide motional feedback for speakers is quite old and has yet to be applied successfully in commercial speakers, to our knowledge. Philips did have a very good range of motional feedback speakers about 25 years ago but they have long since been discontinued.

They have arrived!

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Nominal Current	2.1A	4.2A	5.4A
Fuel consumption	1.1 litres per kWh. 1.3 litres per 100Ah		
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Dimensions	(L x W x H) 435mm x 200mm x 276mm		
Batteries	40 to 200AH recommended		

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pretty much the same as ordinary incandescent bulbs, as can the light distribution.

The mercury problem exists as you suggest but it is hardly going to be much worse than the mercury from the millions of conventional fluorescent tubes already in use. One of the points you do touch on is that replacing incandescents in air-conditioned premises has a double value; it reduces the energy costs for air-conditioning as well as lighting.

One point you do not mention – as far as I can work out, CFLs typically have a power factor of about 0.5 compared with a PF of 1.0 for incandescents. I am not sure what effect this will have on power distribution networks but with large-scale substitution it may become significant.

Finally, I have to agree that replacing incandescent lights is not a major step in energy savings, although if the figures given by Malcolm Turnbull are correct, then households should be able to make a reduction of about 5% or more in energy consumption. As noted above, since commercial lighting is already overwhelmingly fluorescent, the savings in commercial lighting will probably be less significant.

As a final note in the context of global warming, Australia contributes around 1.4% of total man-made CO_2 emissions to the atmosphere – any changes made here will have an insignificant effect.

John Denham,
Elong Elong, NSW.

Comment: the CFLs shown in the article were all obtained within the last nine months. A CFL used in the bathroom of our premises here and installed a few months ago is already seriously blackened at the ends. Temperature rise in poorly ventilated lamp fittings is a serious issue. Most CFLs will have a very short life once their local ambient temperature exceeds 60°C.

We did not mention power factor because we erroneously thought that this was no longer a problem in more recent CFLs. This is quite wrong and it can be a serious problem if large numbers of CFLs are used on one phase of the 240VAC mains supply.

CFLs should work OK in lead lamps; it is continuous vibration that is the problem, whereby internal components are vibrated off their leads.

Dimmable CFLs made by GE are now available from Bunnings and other retail outlets.

More on Edison recordings

"Give 'em A Spin" was an excellent article on the history of recorded sound, in the May & June issues. However I doubt the claim that 4-minute cylinders sounded better than disks of that period. They all sounded rather dismal due to insufficient-sized horns of the wrong shape and limited recording frequency.

Edison utilised the "hill and dale" or vertical method of modulating his recordings, for both cylinder and later diamond disk records. Edison had to employ this method to avoid patent infringement of the Berliner camp. This had the advantage of louder modulation,

Electron flow versus conventional current flow

As a scientist and an electronics hobbyist, I am interested to know why electronics people talk of current flow from positive to negative, whereas scientists talk of current as electron flow from negative to positive. I am thinking that only one of these is actually correct and if that is the case, why isn't a consistent standard in place, preferably with the correct method of current movement along a conductor?

I don't regard the fact that the symbols are wrong, if electron flow is correct as I suspect, as being a good reason to propagate incorrect information to those learning the trade. Information, in all fields of human endeavour, is constantly being updated and corrected, sometimes quite radically and I see no reason why the electronics industry should be different. This might make for an interesting article or editorial.

Robert Oliver,
Perth, WA.

Comment: conventional current flow has always been from positive to negative, in spite of electron flow being the reverse. Most people tend to prefer the concept of something flowing from a positive potential to a negative potential. If electrons had been discovered when batteries were first being developed, then no doubt conventional current flow would be the same as electron flow.

Unless there is a move by some international standards body to establish electron flow as the "standard", there is not likely to be any support for a change. Such a change would have far-reaching consequences; even the arrow on transistors and FETs would need to be changed in direction.

because you only cut deeper into the recording wax. With the lateral system of recording, they had to be careful not to record too loud, lest they break down the record groove.

Edison's diamond disk recordings of the post-WW1 period had better sound than most flat lateral recordings. In 1925, when electrical recording became available, sound quality improved greatly. The Edison Company utilised electrical recording on their late diamond disk recordings from 1927. Their quality is very good.

From this period, they also developed long play recordings. They were perhaps 30 years ahead of their time – because they were played back mechanically, groove breakdown occurred due to the rather heavy mechanical diamond disk reproducer. If Edison had decided to play them electrically, as was possible at that time, maybe history would have had a different turn. They produced 10-inch and 12-inch LP records that played for 20 minutes and 40 minutes in 1927.

Incidentally, the RCA Victor open horn phonograph shown on page 20 the May issue is a fake. These machines turn up all over Australia and are referred to as "Indian Phonographs". Genuine open horn Victors of this period utilise an "exhibition" type mica soundbox, not the type shown on page 20, and the horn has a tapering elbow where the horn connects to the soundbox tonearm. The one shown has a "mitred" joint which is typical of all fake machines.

Don't be fooled by the fake HMV logo; at least they got that right. A lot of these reproduction open horn machines are manufactured from portable gramophone parts of a much later period.

Brian Lackie,
Urunga, NSW.

Delay timer for sensor lights

With respect to the problem of movement-sensor lights staying on due to intermittent power glitches (Ask SILICON CHIP, page 97, May 2007), the best answer is to install a standard on-delay timer with 240VAC operating voltage, set to about five seconds delay. The timer will drop out on any power glitch and not come on again until the power has been steady for the delay period. These are available at any of the electrical trade supply places. The inbuilt relay in the timer will handle the rating of the light.

Mount it in a waterproof Clipsal

Atmel's AVR, from JED in Australia

JED has designed a range of single board computers and modules as a way of using the AVR without SMT board design

The AVR570 module (above) is a way of using an ATmega128 CPU on a user base board without having to lay out the intricate, surface-mounted surrounds of the CPU, and then having to manufacture your board on an SMT robot line. Instead you simply layout a square for four 0.1" spaced socket strips and plug in our pre-tested module. The module has the crystal, resetter, AVR-ISP programming header (and an optional JTAG ICE pad), as well as programming signal switching. For a little extra, we load a DS1305 RTC, crystal and Li battery underneath, which uses SPI and port G.

See JED's www site for a datasheet.

AVR573 Single Board Computer

This board uses the AVR570 module and adds 20 An./Dig. inputs, 12 FET outputs, LCD/Kbd, 2xRS232, 1xRS485, 1-Wire, power reg. etc. See www.jedmicro.com.au/avr.htm

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Mailbag: continued

Update on copyright information

In Barrie Smith's article "Give 'em A Spin", in the May 2007 issue, some information regarding copyright law in Australia was presented in a section headed "Copyright" (see page 23). This appears to have been written without knowledge of changes to the Copyright Act which were enacted at the end of 2006.

By way of background, the passing of the provisions in the Copyright Amendment Act 2006 (hereafter CAA-06) was a requirement of the Free Trade Agreement with the United States of America. Some of the changes in the Act were long overdue and sensible, even though many were worded in such a way as to artificially restrict their scope and limit their application to emerging technologies.

However, these were far outweighed by others (the "technological protection measures) which have the potential to undermine the development of free and Open Source software in Australia. This particular point is a discussion for another time.

With reference to the article, the points presented regarding copyright were correct up until the Copyright Amendment Act 2006 came into force. Some schedules in the Act came into force on 11 December 2006 while others followed 28 days later (schedule 9, dealing with encoded broadcasts) and on 1 January 2007 (schedules 1-5 dealing mainly with criminal provisions, and schedule 12 – the technological protection measures). Refer to the summary presented at **http://www.copyright.org.au/news/newsbytopic/changesnews/u27261.**

Working through the relevant section of the article, you state: "Here it is illegal to make any type of copy of recorded music without the permission of the copyright owner". While this was correct before the CAA06, it is no longer the case. The CAA06 has, in fact, introduced some limited measures which allow copying of copyright material you own for your own private use under certain circumstances.

The practical upshot of this in the plastic box, along with a light switch either on the box or in a convenient spot connected to the light side of the timer circuit to switch the light on permanently when required.

Please note that as this will almost certainly constitute "permanent wiring", it should be done by a licensed tradesman.

Rod Crimps,
Parkdale, Vic.

Incandescent lamp ban has unforeseen repercussions

Your article questioning the banning of incandescent globes in the April 2007 issue no doubt created great interest. I'd like to see a politician replace a fluoro light globe under our second storey eaves. It's rarely used but highly useful from time to time. Fortunately, the incandescent survived 15 years before we needed to purchase a pole and "globe-grabber" to change it.

On the other hand, when an interior night light lamp recently blew, we replaced the 7W "fossil-fuel guzzler" with a 0.5W LED type. The light output is quite sufficient, though the lumens are most likely less than its predecessor.

A politician trolling for votes just mailed a list of pointers to people in our area, extolling energy saving ideas. The tips included "turn off appliances at the power point". Energy and resources were expended producing the glossy card and no doubt old people will now turn off toasters and other appliances that don't have residual current!

Of more concern is the loss of programming and even damage when some devices are turned off at the wall. Turning off a cordless telephone while away for say, two weeks, will ruin the battery, costing money and landfill replacing it. Plus there is the cost, inconvenience and greenhouse gases emitted as people travel in their car to purchase a new one.

The same applies to VCRs. And when a computer's parameter RAM (PRAM) backup battery (as found in

context of the article in SILICON CHIP is as follows:

- If you own a copyrighted musical work, you can now make a copy of that work on a device you personally own for your own personal use, so long as you retain ownership of the original copy. In effect, this now makes the use of MP3 players legal in Australia.
- If you own a copyrighted musical work it is now legal to "format shift"; ie, transfer the work onto a different kind of media for as long as you own both the original media and the copy. So, for example, you are allowed to transfer an LP onto a CD, or an audio tape onto an MP3 disc.

This applies *only* to audio recordings so you still aren't allowed to transfer a commercial VHS work to DVD, for example.

In addition, it is important that the format *must* change – this provision still does not, for example, allow you to make an audio CD copy of an audio CD "for backup purposes". Even so, this is certainly an improvement on the previous restrictions.

The implications of these points are that while it is still true that (as stated in the article) "There is no general right to copy copyright material for personal use under Australian law", these new provisions do grant the owner of physical media containing copyrighted works some restricted rights to make copies of that media. This means that the statement "Ownership of a physical item ... does not give you the right to make copies (including copying into a digital or other format)" is no longer correct.

Note that the CAA06 contained a number of other new useful provisions which are not directly related to this article – such as finally making the use of a VCR for time-shifting legal.

Further details on the changes to copyright law associated with the CAA06 can be found at the URL mentioned above. In particular, the fact sheet at **http://www.copyright.org.au/g096.pdf** may assist in clarifying some of these points.

In addition, the information sheet mentioned in the article at **http://www.copyright.org.au/PDF/InfoSheets/G070.pdf** was updated in December 2006 to reflect the changes I have detailed in this letter.

Jonathan Woithe,
Adelaide, SA.

certain Mac computers) fails due to no charging current for extended times, all the settings you perfected through dozens of decisions are lost; settings like mouse tracking speed, date and time, screen resolution, network and screen depth.

Unfortunately, this misguided switch-off advice can also result in a computer with a blank screen, totally unable to start, requiring a trip to the service department to restore it. Of course there's also the equally high cost of this remedy, emissions from the transport (probably two trips) and landfill too.

Politicians and do-gooders should learn all the repercussions and have a healthy debate with technicians before imposing "pie in the sky" laws and ideas on the public.

Kevin Poulter,
Dingley, Vic.

Digital panel meter assembly problems

I offer the following comments as a result of having built the Panel Meter project from the March 2007 issue.

I bought all parts exactly as per the parts list on page 77. The two Oatley Electronics DPM1 digital panel meters were supplied as 200mV FSD devices, not 0-20V as stated in the article. This meant that the setting-up and calibration of each meter was much more difficult. The descriptions and instructions provided by SILICON CHIP, Oatley Electronics and the DPM manufacturer were oversimplified and incomplete and a lot of experimentation had to be done in order to get the project working.

The brief slip of paper included with each DPM is intended to give instructions on how to add resistors to the DPM PC board so as to make "multipliers" or voltage dividers to convert the DPM from 200mV FSD to the desired value, in this case 20V or 20A. There are also instructions on how to set jumpers to control the decimal point position.

For a maximum voltage of 20V, we are told to "Disconnect wire jumper in

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Mailbag: continued

CINLIST is independent of trade associations

I would like to point out an error in the "Serviceman's Log" in March 2007 on page 85. In his article, the Serviceman recommends "an excellent chat-room service for members (of TETIA and TESA) called CINLIST".

While we appreciate the credit given by the Serviceman to the CINLIST and to other technicians (including Dave Elliott of Victor Electronics, SA) who helped him with the Philips 32PW4523/75R TV, we would like to point out that the Certified Electronics Technicians' Association (CETA) set up and runs the CINLIST. It is an acronym for CETA INFORMATION LIST. It has absolutely nothing to do with membership of ANY trade association and is run purely for the benefit of the Electronics Service Industry, both here in Australia and across the ditch in New Zealand.

There are over 200 technicians who subscribe to the CINLIST and many of them (not all, unfortunately) donate money towards its upkeep. All the fault information that passes through CINLIST (including this particular Philips TV) is entered into a database and made available to subscribers, for a small fee, as a CD ROM.

This is a service that CETA provides to everyone. The CINLIST is "moderated" and we also attempt to keep it free of advertising, although some do take advantage of our good nature!

Martin Shepherd,
Executive Officer, CETA.

R_B, R_A = 100 K, R_B = 9.9 M". But the "wire jumper" is in fact a zero-ohms surface-mounted resistor soldered to the PC board and I spent quite a lot of time looking for the wire jumper. Unsoldering the SMD was easy once the penny dropped.

Next came the search for a 9.9MΩ resistor with 1% or better tolerance – of course, they are unobtainable from normal sources. After much head scratching, I decided that this was only a multiplier after all, and the input impedance doesn't really have to be 10MΩ for a 20V meter and about 2MΩ would be more than adequate. A little elementary arithmetic shows that for a multiplier ratio of 100:1, R_A has to be equal to $R_B/99$.

I decided to use all 1% resistors from Jaycar. R_B would be made from the series combination of 1MΩ and 820kΩ, and R_A from 18kΩ and 390Ω resistors, all 1% tolerance. Unfortunately this was not good enough, because the actual values of the various resistors were too far away from their nominal values.

I ended up selecting individual resistors from the pack of eight of each size, eventually reaching a compromise that gave a real-life multiplier ratio of 100.1:1. In each case (R_A, R_B), two resistors in series had to be fitted on the PC board where space was provided for one, which is not very tidy.

The ammeter shunt resistance calculation on page 78 is wrong. For a meter of 200mV FSD the shunt should be 0.01Ω (200mV divided by 20A), not 0.0125Ω. The wire supplied therefore should be 200mm, not 250mm long if its resistance is 0.05Ω per metre. If it is left at 250mm the meter will read over-scale (displaying "1.") at only 16A. Alternatively, if full scale is to be 25A, then the shunt should be cut shorter to give only 0.008Ω, or 160mm. I left it at 200mm to read full scale at 20A.

The Oatley shunt board was easy enough to make but there are some vital instructions left out. This board is apparently intended to be used over a wide range of meter full-scale values and there are six PC board points intended for fitting of links or jumpers to cater for the various possibilities. There are no instructions except a circuit diagram, from which the user has to work out the intentions of the designer, bless him.

For this application, links have to be fitted between A and C and between B and F. In addition, there is a final trimming adjustment in the form of a 10kΩ pot across the shunt to compensate for minor errors in the shunt resistance value.

The ammeter DPM can be left to read 200mV FSD but the decimal point jumpers have to be set to display 19.9 instead of 199, etc as per the brief instruction sheet.

The above all sounds logical enough in hindsight but in order to get there I had to partially dismantle the whole thing in order to diagnose the reason for crazy displays when first assembled to instructions. The shunt board was first unsoldered from the ammeter DPM, the shunt was removed from the screw terminals and re-cut, and PC board posts were soldered into the six holes A-F.

Next, the 10MΩ and 100kΩ resistors R_A and R_B on the voltmeter board had to be removed and the board tidied up and examined for damage. Finally, the shunt board was temporarily connected again to the DPM posts via 150mm lengths of wire so the whole project could be tested and calibrated in an open state, and the various jumper settings verified without having to unsolder the two boards again.

In retrospect, the final calibration of the two meters was relatively easy. For current, I used a 2A 0-16V lab power supply working through a large 0-20Ω wire-wound rheostat for low end calibration, and a 12V SLA battery loaded up by a variable length of large gauge resistance wire for the high end.

In each case, my "substandard" against which calibration was done was the best available DMM or other bench meter that I could lay my hands on.

After plotting and averaging, I think I've ended up with a couple of meters that will read around ±2.5% of true voltage or current. NATA, look out.

Bruce Rabbidge,
St Ives, NSW.

Comment: what can we say? The supplied instructions with the panel meters are very poor and our article should have compensated for those shortcomings.

Cheap multimeters can double as panel meters

Recently, I thought about building your simple panel meter project from the March 2007 issue. Then I was in

a local shop called "Cheap As Chips" and noticed small pocket digital multimeters for $5.00 each. DT810B was the model number on the meters and the product code HA3068.

These meters had a 10A range so I purchased two for $10.00 a pair, wired them up so one was a 20V voltmeter and the other a 10A ammeter. The whole unit then only measures 90 x 95mm. They use an A23 12V battery in each meter.

For the meter used as 10A meter, I wired heavy leads to the terminals on the PC board, as the tracks are a little thin. This makes a very cheap project. One wonders what these meters really cost to produce in China.

Keep up the good magazine. I started with *Radio & Hobbies* magazine then *Electronics Australia* and now SILICON CHIP. I have been following these magazines for just over 40 years.

D. L. Bishop,
Yorketown, SA.

We have a long way to go with energy conservation

I recently attended the pool and spa show where the majority of the displays were spas. A lot of interest was being shown in the spas, so out of curiosity I looked at the specifications of a medium to large size spa. It had three motors, one 5HP and two 3.5HP.

This is just to run the jets. How much more energy is used in heating the water and keeping it at a comfortable temperature? The government is going to do away with incandescent lamps but how many houses are going to have to convert to fluorescent or LED lighting just to equal the energy used in one of these spas?

Glen Williams,
Heathcote, NSW.

Ignition coil for Jacobs Ladder project

When building the Jacobs ladder kit featured in the April 2007 issue, you need to use a Commodore VN Series 2 V6 coil. The VN Series 1 coil contained three coil packs in one. The three separate coils arrangement carried on through the VP to VS and possibly even through to the VY.

Also, a firmware alteration could be made on your Intelligent Air-Conditioner Controller (SILICON CHIP, January 2007) to turn off the condenser-cooling fan once the vehicle reaches a certain speed. The airflow through the condenser and radiator is much more than a fan can push once the vehicle is over 40-50km/h. This would minimise fan motor wear and a small energy loss.

In a previous job as a Holden motor mechanic, I observed this function via a diagnostic tool. The engine management computer switches off the radiator fan at a certain speed. The tool indicated that the compressor clutch was still engaged, so it wasn't the cycling of the compressor. The vehicle was a VN Commodore. I thought this information might be handy.

Peter Harland,
Shepparton, Vic

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You may not be aware of it but without going to any real expense, you can make major energy savings at home and in the office. Nor do you have to make any compromises in day-to-day comfort. All you have to do is be aware of what all your appliances actually consume and then take appropriate action.

How To Cut Greenhouse

. . . and save real $$$$ into the

We are all told – increasingly often – to turn things off, use less energy, use energy efficient appliances.

But it helps to understand how much appliances and activities use, to know what to concentrate on.

To give an example, it makes no sense to turn off just a lamp in a room where an electric heater has been left on. The power used by the lamp may be 100 watts while the heater draws 2000 watts or more.

The 100W light globe

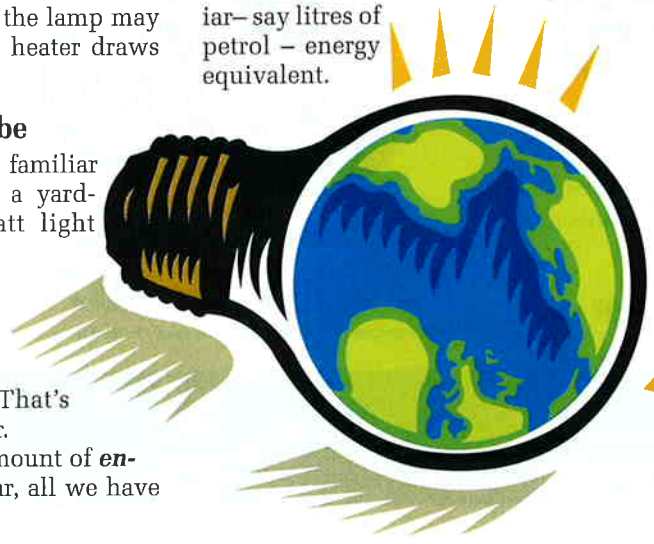
To start, let's pick a familiar energy-using object as a yardstick, say the 100-watt light globe.

How big a yardstick is 100 watts anyway? Let's assume that a globe is on every night for six hours. That's about 2200 hours a year.

So to work out the amount of ***energy*** used over that year, all we have to do is multiply hours by watts to get the energy in a unit called watt-hours: 2200 x 100 = 220,000 watt-hours.

To make it more manageable, we divide that figure by one thousand to get 220 kilowatt-hours, abbreviated to 220kWh.

To many people, a number like 220kWh doesn't mean much – so let's convert it into something familiar – say litres of petrol – energy equivalent.



A litre of petrol contains about 10kWh of energy. A kWh is 3,600,000 watt-seconds which is 3.6 megajoules (3.6MJ; a joule is a watt-second).

An unfortunate consequence of the laws of thermodynamics is that the process of producing electricity by burning fuels is not very efficient.

The best that can be achieved by burning brown coal to generate electricity (as is done in Victoria) is 25%. So four times as much energy is used to deliver what ultimately comes through your electricity meter box and power points.

So 4 x 220kWh of fuel to produce that electricity = 880kWh. Translated into litres of petrol that comes out to 880/10 = 88 litres – enough for the average car to drive 880km or from Melbourne to Sydney. Surprising isn't it? That's just to run one 100W light globe each night for a year.

Black coal electricity generation is more efficient – about 30%. So the

Part 1
by Peter Seligman, PhD

Your Emissions bargain!

figures for other states are 660kWh and 66 litres, etc. A seemingly insignificant light globe used every day goes through a lot of fuel (and energy) over a year.

Another way of looking at this is the amount of carbon dioxide (CO_2) that is produced to run the light globe compared to the CO_2 produced by a car being driven a certain distance. Because coal produces more CO_2 for the same energy than liquid fuels, the equivalent distance for the light globe is over a 1000km.

Ready for another surprise?

You turn on the taps and jump into the shower. I won't go into the issue of how long you might stay in there but let's look at how many light-globe equivalents of power is used while the shower is running.

If we are talking about an electric hot water service, these are generally heated at night over a period of about six hours – well, slightly less because they build in a safety factor to take into account very cold weather – let's say five hours.

The normal heating element in an electric hot water service is about 4800 watts (4.8kW). Translating that into 100W units – that's 4800/100 = 48 light globes. Now let's look at how quickly that water could be used. How long would it take to drain your hot water service if you just showered on until it ran out? About one hour?

OK, so that means you can drain it five times faster than re-heat it. So while that hot water tap is on, the energy going down the drain, is the equivalent of – wait for it – 5 x 48 = 240 light globes!

I suspect many people, if they could see the 240 globes shining while they were showering, might take much shorter showers.

Common myths

Now let's get onto some common myths and misconceptions.

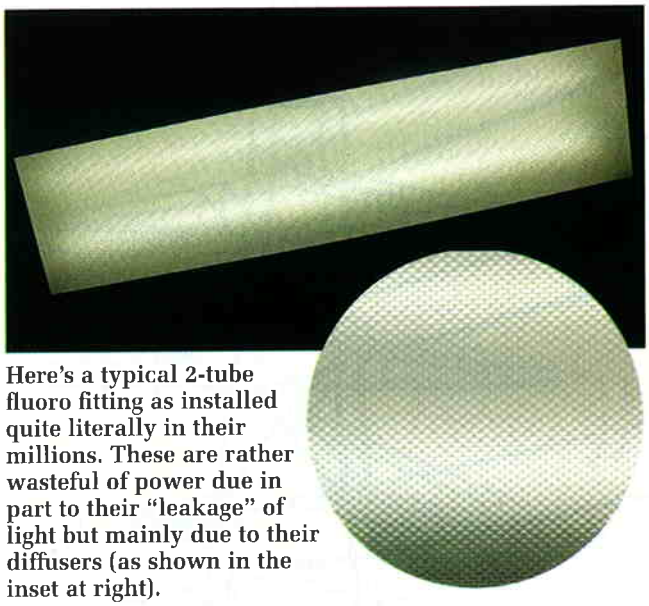
Myth 1: how many of us have heard that fluorescent lights are very efficient?

It is certainly true that fluorescent lights are much more efficient than incandescent lights. Here the main problem is the sheer numbers of lights installed. A typical 1 to 2-person office may have four twin tube fittings.

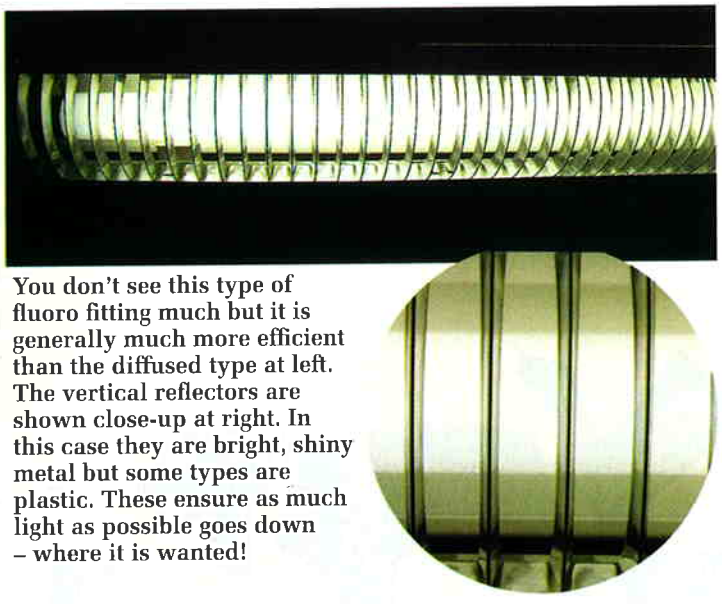
I'll let you in on another secret. The tubes may be rated at 36W but the complete fitting (which includes a transformer-like object called the ballast) uses closer to 50W. In a twin tube fitting, that's about 100W so the office comes to four incandescent light globes.

I was amused the other day when a friend was leaving his office. He turned off the 50W desk lamp (to save energy – "well, it felt hot!") and left on 400W of fluorescent lamps (because they hardly use any energy – you don't feel the heat from those, unless you are up close).

Myth 2: have you heard that it takes more energy to switch lights on and off than leave them on? This is a popular



Here's a typical 2-tube fluoro fitting as installed quite literally in their millions. These are rather wasteful of power due in part to their "leakage" of light but mainly due to their diffusers (as shown in the inset at right).



You don't see this type of fluoro fitting much but it is generally much more efficient than the diffused type at left. The vertical reflectors are shown close-up at right. In this case they are bright, shiny metal but some types are plastic. These ensure as much light as possible goes down – where it is wanted!

one because it is so convenient to believe.

But it isn't true. Its origin can be traced to a time when fluorescent tubes were new, expensive and their life was shortened by frequent switching. But in terms of energy – an hour switched off is an hour's worth of energy saved.

And it doesn't use even a little bit more when you switch it on again. Today's tubes last for tens of thousands of hours whether you switch them or not and they cost about $3. The rationale for leaving them switched on has long passed – if it ever existed.

This myth was recently thoroughly debunked on the American "Myth Busters" show on SBS. If you are to leave the room for more than 10 minutes, turn the lights off.

Here's another tidbit of information: in an air-conditioned building, it takes 30W of air-conditioner power to extract every 100W of heat generated (by the lights or anything else). So a 100W fitting effectively uses about 130W once you take air-conditioning into account.

You might have the impression from what I have said that fluorescent light tubes are very inefficient. Not at all! They are amongst the most efficient means of lighting – in fact they are more efficient than compact fluorescent lights (CFLs).

The problem is the way they are used and over-used. A single unencumbered tube can adequately light a kitchen-sized room or office. Recessed lights with diffusers waste a lot of the light. Newer fittings with reflectors and no diffusers are much better.

Finally, you will be surprised when you change older tubes for the new Tri-phosphor types. Their light output is so much higher that you can omit one-third of the tubes and still get the same light level.

12V halogens are huge power wasters

Let's now look at low-voltage downlights, ie, 12V halogens. Whoever thought that these were a good idea?

Not only do they only light a small area, they use lots of power. Because of the 240VAC to 12VAC step-down transformer, each downlight, rated at 50W, actually uses about 60W.

Many consumers believe low voltage means low energy – in fact, you often see adverts implying this. And if you ask any salesman in a lighting store, well . . .

But nothing could be further from the truth.

The main problem with these lights, apart from their inherent inefficiency, is that too many must be installed to get adequate lighting. It is not uncommon to find six or more in a kitchen – another 400W.

But there is light on the horizon: a LED with higher output than a 50W halogen has just been announced (see p15).

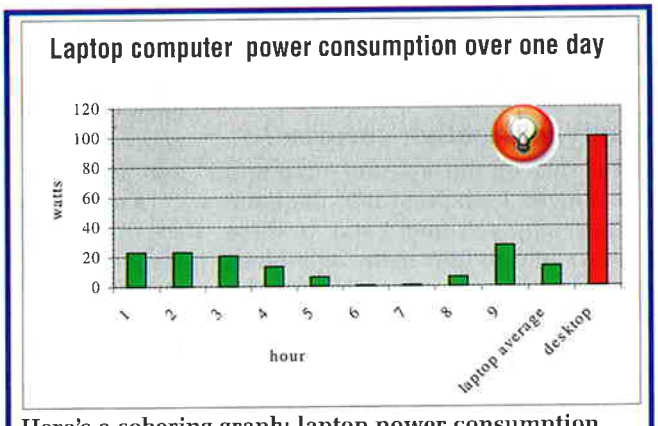
CFLs?

As far as CFLs are concerned, see the comprehensive article in the April 2007 issue. In general they cannot be regarded as direct replacements for 12V halogens.

However, there are now compact fluorescent replacements which only use about 11W. Don't get fooled by the ads, the 9W watt ones are not as bright. I have tried 18-watt incandescent replacements which seem to be quite satisfactory for spot or feature lighting.

Computers, too!

Desktop computers are another power hog. How many of us have a desktop computer churning away all day and maybe all night, too. These



Here's a sobering graph: laptop power consumption versus that of the average desktop! With the performance of today's laptops, which would you go for?

This entertainment unit has 10 different devices all consuming standby power day in, day out – from the TV itself to a satellite TV receiver, digital set-top box, DVD and CD players, DVR and even a couple of VCRs (count the remotes!). The total is revealed as a whopping 55W by the SILICON CHIP Energy Meter (published July/August 2004). That's 1.3kWh per day or 481kWh per year.

typically use about 120-160W – some significantly more – although this drops to about half if the monitor switches to standby.

Nevertheless, on average it may be about 100W for eight hours per day or more. Think in terms of that Melbourne to Sydney trip each year.

The good news is that laptop computers use only about 25W – and even less on standby (my laptop uses a remarkably low half a watt of mains power on standby).

LCD monitors also use less power than CRT monitors – about 20W.

The only reason to leave a computer on continuously is if it is very close to the coast. A cooling computer (after you turn it off) is bound to condense the moist, salt-laden air which the fan has drawn in – with usually disastrous results in just a few months.

Standby power – the "hidden" energy gobbler

You should be aware that many appliances and electronic devices, particularly those in the entertainment area, use power all the time – even when they are "switched off". Of course, they are not actually "off".

This "standby power" is largely unnecessary. Until recently, designers didn't give this aspect much attention. The result is that many modern appliances can use more energy on standby than doing their job, because they are left permanently on.

As an example, consider a typical new washing machine with electronic controls rather than a simple mechanical timer. On standby, when it is doing absolutely nothing, it uses about 5W or 120 watt-hours per day. The machine uses about 50 watt-hours (not counting the energy to heat the water, which is less common these days with "cold water" detergents) to do a load of washing. Its direct drive motor is superbly efficient but for the rest of the day it uses 120 watt-hours doing nothing!

The solution: simply turn it off at the power point.

It is the sheer numbers of these appliances which is the problem. We have microwave ovens, TVs, VCRs, DVD players, sound systems, all with their individual clocks and displays. A typical household might have 10 such units. So unless an appliance actually has time setting functions you need to program – switch it off at the wall. Is there really any need for the TV to sit there all day and night just waiting for you to press the remote control?

(Editor's note: some home theatre and other entertainment equipment cannot be turned off or you will lose all your preferred settings – another case of bad design).

Here's another example along those lines. My son recently installed a new split-system air-conditioner. It's a 5-star rated system but here's the surprise. This air-conditioner draws 10W on standby. Let's do the calculations: 10W for 24 hours a day, 365 days a year comes to 88kWh per year.

Now let's work out the likely usage when it is running. In Melbourne, there are perhaps 20 hot days a year, when it would be used for eight hours and for those eight hours it would run nearly flat out.

That's a crude assumption but it will serve as an illustration. Running flat out, it draws 550W. At eight hours for 20 days, its air-conditioning energy consumption comes to 88kWh per year! So this 5-star rated appliance uses as much energy on standby, as when it is doing its job. That's just crazy.

What to do? Get a switch installed so you can just turn if off completely for most of the time.

And do you really need all those devices with digital clocks, showing the same time in every room (and sometimes two or three per room!), all chewing up "standby power" 24 hours a day?

Solar energy? Umm, well . . .

Finally, let's get onto solar. Why don't we just go solar? This is excellent for water heating. You won't have to think about 240 light globes, just about wasting water.

Actually, water isn't just water. There is a substantial energy cost in delivering water to consumers. Think about the infrastructure cost (and

energy input) to build and run dams, pipes, pumping stations, water treatment (filtering & chlorination), then sewage pumping and treatment.

But solar for electricity? Well let's do the sums. It costs about $10 to provide a watt from a solar panel in brilliant sunshine, when the sun is shining straight onto the panel. Panels are sold by this "peak" power.

However, you have to take into account the varying sun angle, nighttime and the weather. For Melbourne or Sydney you would find that average power is about one seventh of the peak power. That's right, one seventh. They don't tell you that in the glossy brochures.

So an average "solar" watt costs about $70.

Then there are the frames, the installation cost, wiring, etc. Generally that doubles the cost again. In some states the government will pick up a proportion of the cost.

But think of it this way: how much does it cost to save a watt?

Changing an incandescent globe to a compact fluorescent saves on average usage (80 watt saving for say 6 hours out of 24) about 20W.

Cost to make the change? About $7. Replace 10 times over 20 years – say $70.

Cost of a solar system to provide an average of 20W? Wait for it: $20 x 70 = $1400. Or if the government is paying half, about $700.

In this example, it costs10 times as much to provide the power as it costs to save it in the first place!

Huge potential for saving

I hope I haven't depressed you too much but there is good news! The potential for saving energy really is huge – if you just understand where it is all going.

I was sitting with my colleagues having Friday afternoon drinks in our lunch room when I thought about how to present these ideas to them. I counted the double fluoro fittings. Six hundred watts to light a room which has large windows right across one wall.

"Look at these lights" I said. "There's no need for them to be on at all". "Look at those spotlights – lighting the floor behind the desk – when would they ever be useful?"

They looked at me askance, as if I had suggested that missing dinner was a good energy saving measure.

Were these the same colleagues who asked me if I had seen the Al Gore movie? (I hadn't).

But why would anybody who was troubled by the Al Gore message think that even these trivial "sacrifices" were asking too much?

I didn't even get to point out that we had a total of 6000W of lighting switched on. You see the office only has three switches, which are not zoned in any sensible way – so we were lighting the whole office while we were using only one room!

A couple of hours of an electrician's time fitting new switches could cut this significantly. As it is now, say 10 hours per day (it's probably more) x five days a week (often six!) x 52 weeks x 6000W . . . 15.6MWh!

How many times did you say you wanted to drive from Melbourne to Sydney and return each year? Want to detour via Perth and Darwin as well?

In the next part of this article, we will investigate how to make big savings in water heating and space heating. SC

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A LED to replace 50W halogens?

Elsewhere in this issue (and indeed previous issues of SILICON CHIP) we rail against the huge energy wastage of all-too-popular halogen downlights). Perhaps their days are numbered . . .

Just over 12 months ago (June 2006), we brought you news of a (then!) super-bright LED whose brightness exceeded that of a 20W halogen. With rapid advancements in the LED field, the next brightness hurdle – that of the 50W halogen – has been jumped.

Osram has developed a light-emitting diode (LED) spotlight that achieves an output of more than 1000 lumens. That's brighter than a 50W halogen lamp, making the device suitable for a broad range of general lighting applications. The Ostar Lighting LED, scheduled for release within months, can provide sufficient light for a desk from a height of two metres, for example. Its small size also enables the creation of completely new lamp shapes.

A lumen (lm) is the unit of measurement for the amount of light emitted by a light source. A typical 60W light bulb emits 730lm, while a 50W halogen lamp has an output of approximately 900lm. To achieve the 1000lm output of the tiny Ostar Lighting LED, Siemens' Osram subsidiary managed to integrate six high-performance LED lighting chips into the unit's small housing. Each chip has an area of only one square millimetre, which makes for very concentrated overall luminosity.

Different types of LEDs are used today in various areas, for example as background lighting in cell phone displays, as well as in car turn-signal lights, brake lights and daytime running lights. They're also rapidly replacing incandescent bulbs in traffic control lights. The benefits are obvious. The LEDs are extremely small and consume little energy because they efficiently convert electricity into light.

The Ostar Lighting LED, for example, produces 75 lumens per watt at a current of 350mA. By comparison, a standard incandescent lamp, at around 12-15 lumens per watt, converts only a fraction of the electricity supplied into light. The rest is lost as heat. Halogen downlights are marginally better at about 18-25 lumens per watt. An even better idea of the efficiency of the Ostar LED is that its 12V, 50W halogen competitor requires a 4A supply.

In addition, LED lamps last around 10 times longer than halogen lamps and 50 times longer than incandescent lamps, thereby helping to significantly reduce maintenance costs. They contain no lead or mercury, which makes them very environmentally friendly.

Until now, LEDs have been unsuited for room lighting because they weren't bright enough. The Ostar Lighting LED marks a big step forward – we could soon see lots of LEDs in home lighting.

Osram has developed a LED spotlight that achieves an output of more than 1000 lumens for the first time. That's brighter than a 50W halogen lamp but without the heat, thereby making the device suitable for a broad range of general lighting applications. The Ostar Lighting LED will be launched on the market this year.

Osram has already supplied a Migros supermarket in the Swiss canton of St. Gallen with 18,000 Golden Dragon LEDs, which have a lower output than the Ostar Lighting units.

These LEDs emit neither UV rays nor heat, which means they have virtually no negative impact on delicate grocery items such as milk, meat, fruit and vegetables. SC

Watchguard™ Pro Video

Catch 'em in the act!

It seems these days it's not enough to protect your property – if the b**s want it enough, they'll go to extraordinary lengths to steal it. What you need is the evidence to help catch them – and this could just do it for you!***

The idea of recording intruders is not exactly new – it's been around even before Adam bought Eve their first Betamax VCR.

In recent times, VCRs have been replaced by DVRs, or Digital Video Recorders. The difference is that in a DVR, the image is recorded directly to a hard disk instead of going onto tape.

The main advantage of this is that recording times can be very long indeed, limited only by the size of the hard disk drive (and these days, that's huge!).

DVRs also aren't exactly the latest kid on the block – they've been around for a few years now.

But this "Watchguard" DVR4ENTPACK system, submitted to us for evaluation from RhinoCo Technology, seemed to us to be the ideal security solution for two reasons: the quality of the images (how often have you seen almost unrecognisable CCTV images of crooks on TV?) but more importantly, everything comes in the box.

When we say everything, we mean it: the 4-channel DVR (more on this in a moment) with 80GB hard disk drive. It also has four day/night weatherproof colour cameras (two with 15m range and two with 30m), two switch-mode power supplies (one for the DVR and one to power the cameras), four camera connection cables (2x 10m, 1x 20m and 1x 30m) a power split cable (allows all four cameras to run from one supply), a monitor connection cable, a network connection cable (more on this shortly, too!), a quick installation guide and a CD containing not only a more comprehensive instruction manual but the software you'll need to drive the system.

About the only thing that isn't supplied is the video monitor - this can be a purpose-designed monitor or can be any TV with video inputs (as are about 101% of TVs on the market today).

The DVR

This, as we mentioned before, is 4-channel – that is, it is capable of recording all four camera inputs at once. It records with advanced MPEG4 Compression which not only gives high quality images but more importantly, small file sizes. At first glance, the control panel looks quite complex but after a few minutes it will be as easy to use as your home video.

The video is capable of a number of modes of operation – manual, timed and also "intelligent motion" recording triggered by movement across one of the camera's fields of vision.

Once a recording is made, it can be searched and then viewed in slow motion and frame-by-frame.

The DVR can also be connected to an IP-based network or to the internet for remote operation/viewing.

This involves setting an IP address, configuring port forwarding and then running the appropriate (supplied) viewing software.

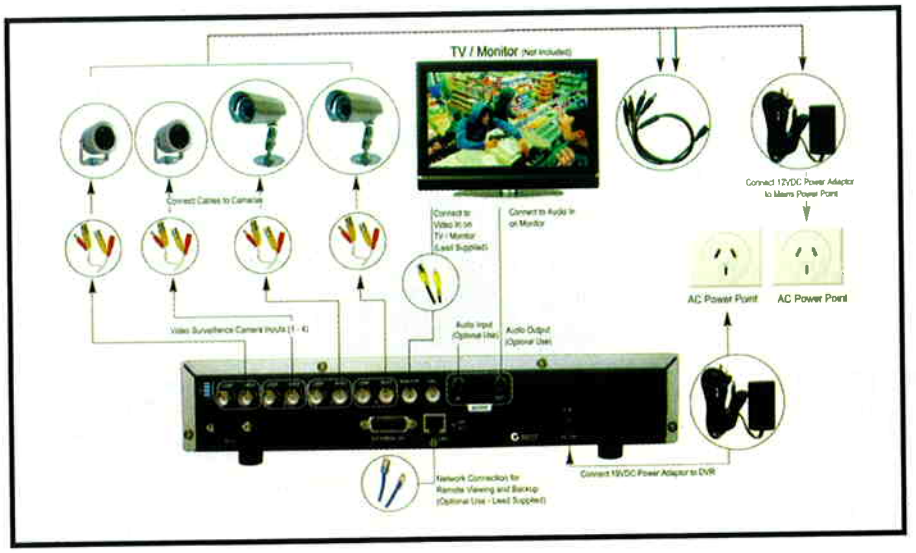
Watchguard warn that this should be done by someone with networking/internet experience.

As supplied, the DVR is set for "CIF best quality", at three frames per second per camera, at a resolution of 352 x 288

Everything you need is in the box – the digital video recorder, four cameras, camera mounts, two power supplies, all the cabling, instructions (both printed quick guide and full on disc) and the software you need to use the system on the 'net.

Security System . . .

Review by Ross Tester



pixels. This will give around four weeks of recording time. Using Video Motion Detection will obviously extend this.

If you want higher resolution/more frames, you can set it to record up to 6.25 frames per second per camera in frame mode, 720 x 576 pixels, high resolution (MJPEG compression). You also have the option of continuous video at 25 frames per second in CIF mode (real time), MPEG4 compression, 352 x 288 pixels.

The cameras

Two long range and two short range colour cameras are supplied. All are weatherproof so can be used indoors or out. They use high quality CCD sensors (not CMOS) and all have infrared LEDs for illumination in total darkness (B&W mode). The long-range (30m) cameras have 24 LEDs while the 15m versions have 12 I-R LEDs. Both offer 420 lines vertical resolution, 520 x 582 pixels.

The long-range models also include an adjustable sunshield (or bright light shield).

The verdict

Given that everything you need is supplied and also given its internet capability, this appears to be an ideal system for business or the home.

Recommended retail price of the system is $1196 – available from Dick Smith Electronics or call 02 4577 4708 or visit www.watchguardalarms.com.au

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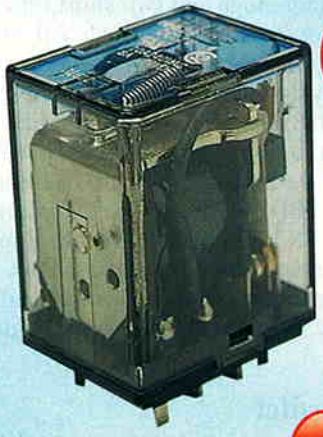

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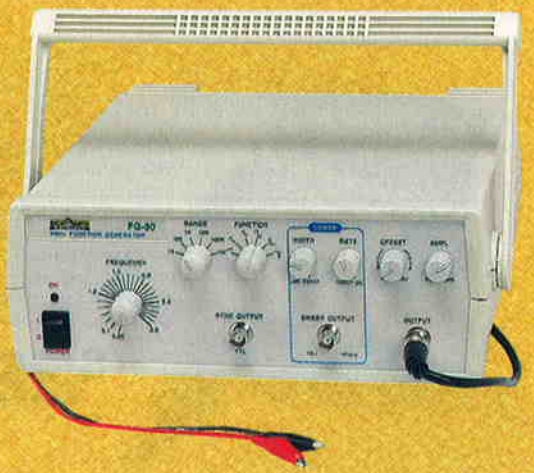

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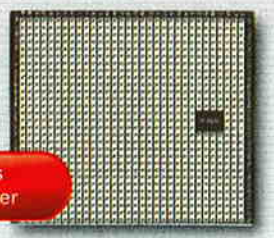

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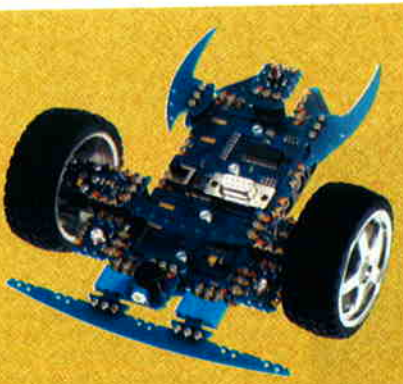

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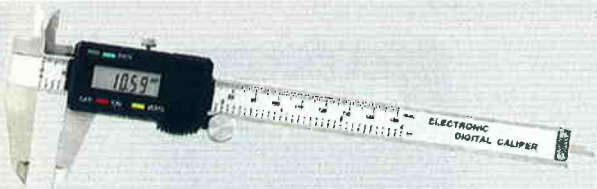

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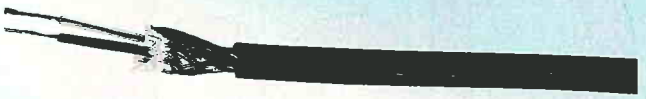

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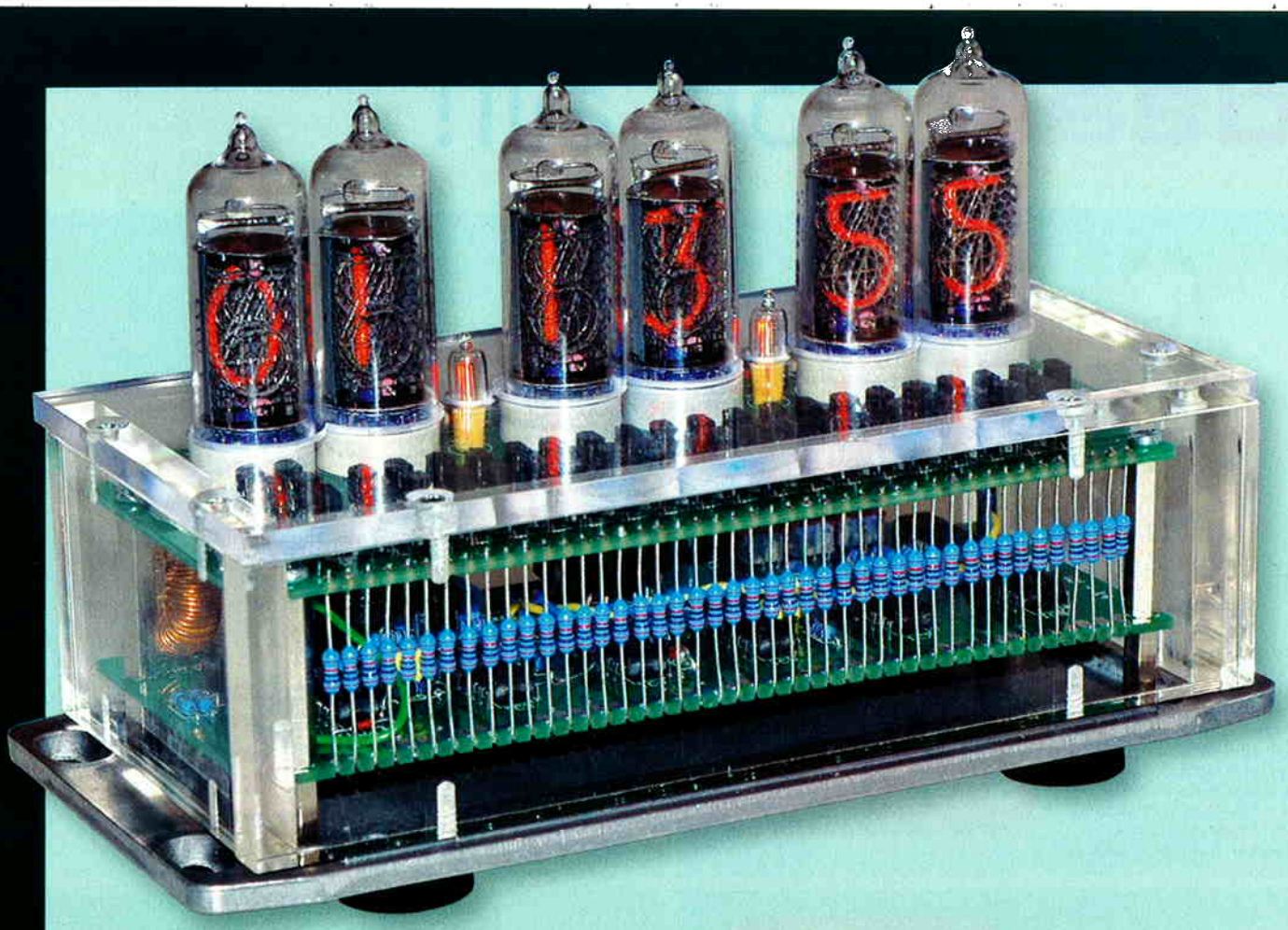


Nixie Clock

Eye-Catching Retro Project To Build

We have been wanting to produce this Nixie Clock project for a long time and now it has finally come to fruition. It has the warm, fascinating glow of Nixie tubes with their hypnotic counting action, mixed with a cool blue glow from a high-brightness LED from underneath each tube. It makes an eye-catching display, both during the day and at night.

Pt.1: Design by DAVID WHITBY

Two different cases will be available – either a see-through Perspex case as shown at left or a white powder-coated diecast aluminium case as shown above. By the way, the photos really don't do the brightly glowing Nixie & LED displays justice.

IF YOU DO A GOOGLE search for "Nixie Clock" you will immediately find over 200,000 results. Many of these refer to actual Nixie clock designs or clocks that enthusiasts have built. Some are quite eye-catching, some are downright ugly and some are truly weird. We feel quite safe in stating that none looks as good or is as well-designed as the Nixie Clock we are presenting here.

Not only does it function as a classic 6-digit 12-hour clock, with hours, minutes and seconds display, it also uses blue LEDs to throw light up through the Nixies – a neat juxtaposition of the nostalgic warm neon discharge with the cool blue present. It keeps accurate time with crystal control and the retro "Nixie" tubes with their moving and glowing individual numbers give it the atmosphere of an earlier techno age.

What is a Nixie?

A Nixie is, or was, one of the first numeric displays. It has 10 individual electrodes, from 0-9, placed one behind another. Each electrode is lit with a neon discharge to display a particular number. Before Nixies, alphanumerical displays were mainly electromechanical indicators or incandescent filament devices which the compact, silent and reliable Nixie soon outshone.

The Nixie was invented by the Haydu brothers in the USA in 1952 who later sold the design to Burroughs Business Machines. It appeared in vast numbers in the late fifties and sixties as the display of choice for calculators and other business machines, various kinds of test equipment and early computers. They displayed the trading information at the New York Stock Exchange and showed crucial data in those epic control rooms during the space race.

The Nixie name came from an original prototype drawing which was entitled "N I X 1" meaning Numerical Indicator eXperimental 1. The name stuck and has been used ever since. Nixies were made in a vast range of different shapes, sizes and colours and tubes with many different symbols apart from numbers were manufactured.

From the early 1970s, they were rapidly displaced by 7-segment LED and vacuum fluorescent displays, and ultimately by liquid crystal displays (LCDs). Funnily enough, today's plasma displays can be regarded as an evolution from Nixies – they are both gas discharge displays.

Nixie tubes have not been manufactured for many years and are becoming rarer and more expensive, so if you want a lasting and useful piece of retro technology, now is definitely the right time to build a Nixie clock.

Circuit description

Now let's take a look at the circuit – see Fig.1. Big, isn't it? But this is relatively low-tech stuff with not a microprocessor in sight.

As shown, there are six Nixies, with their cathodes each driven by a high-voltage transistor, 44 transistors in all.

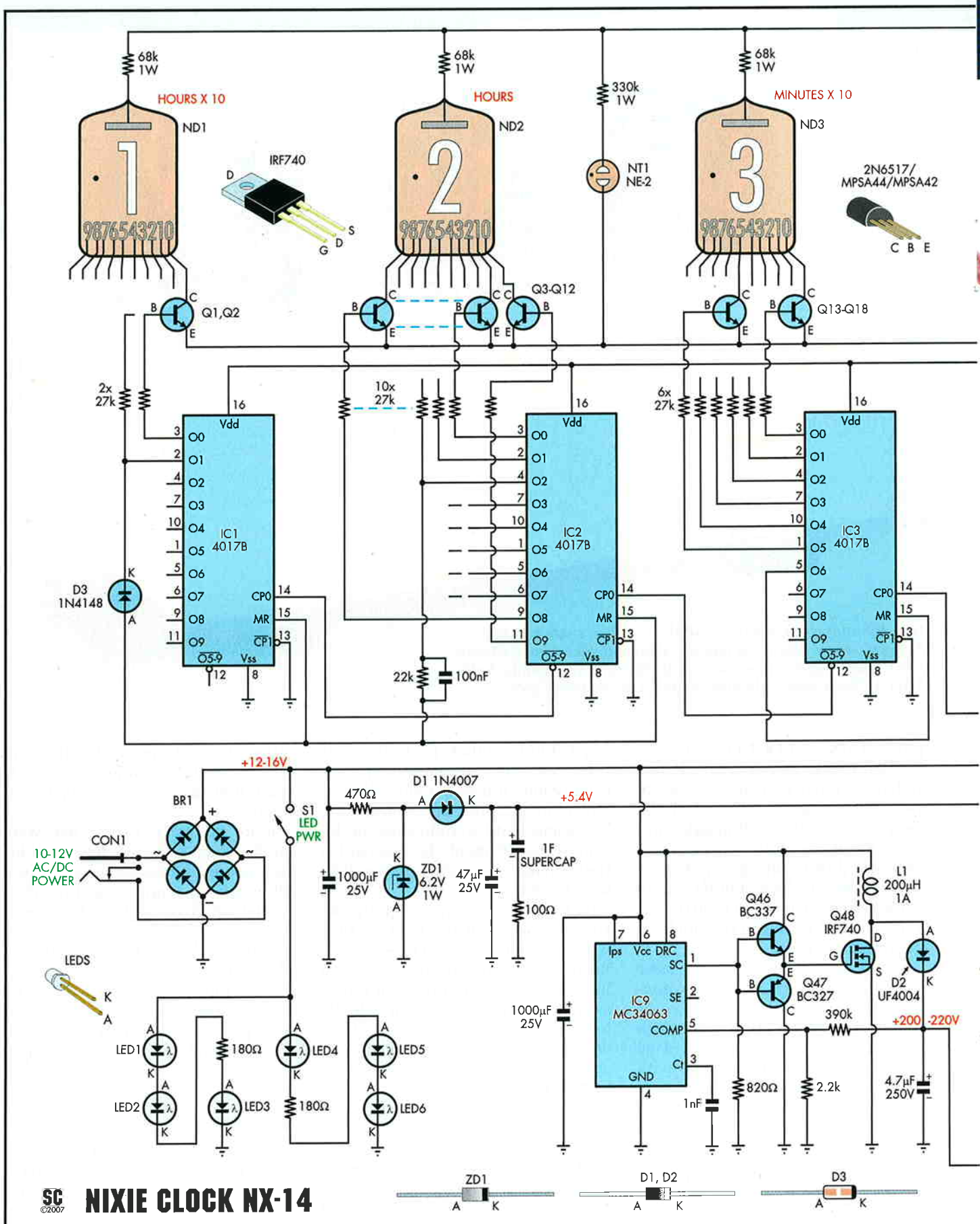
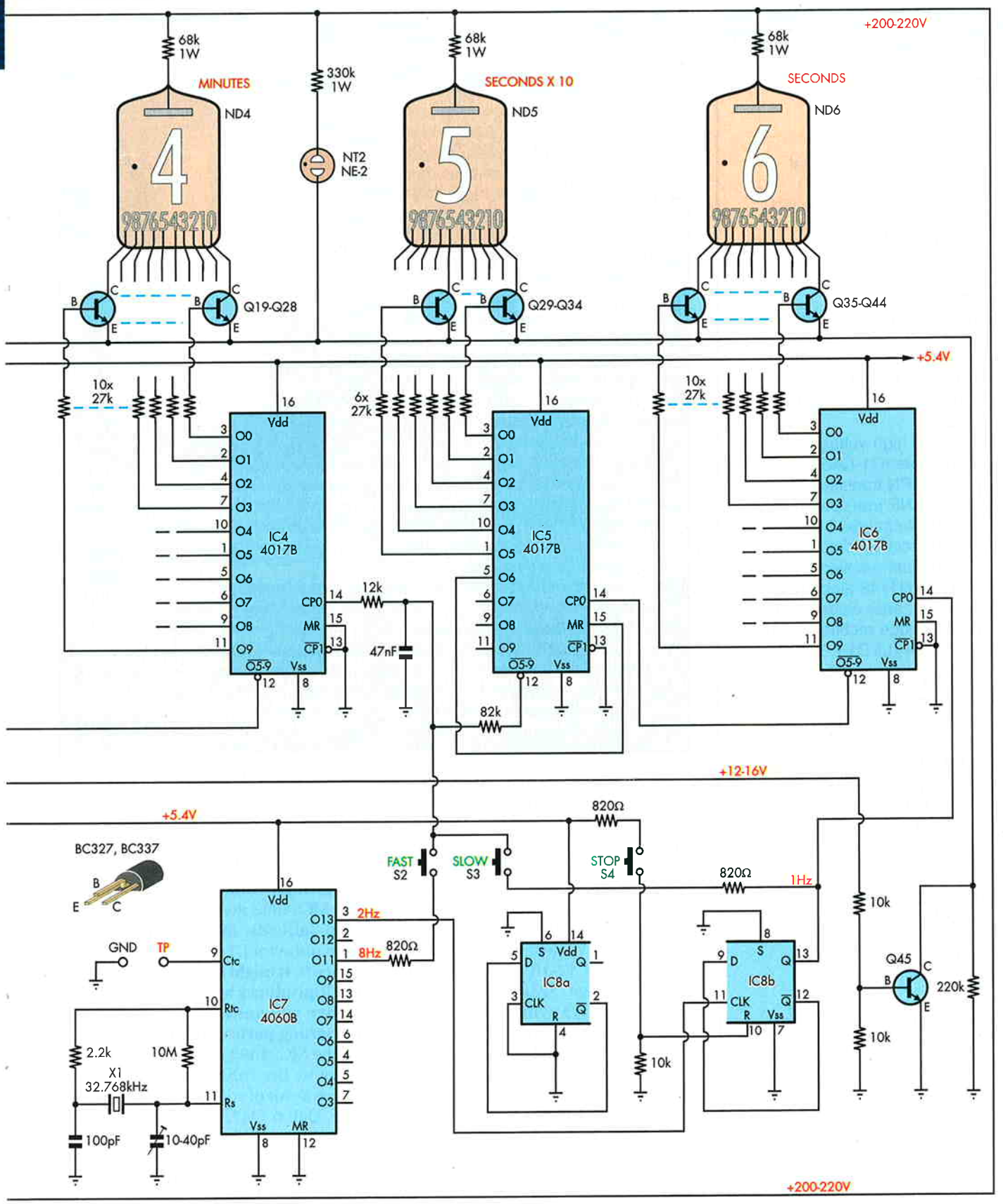


Fig.1: the circuit uses six Nixie tubes, each driven by a 4017 decade counter via high-voltage transistors. Switchmode controller IC9 and its associated parts provide the high-voltage (200-220V) DC supply for the Nixie anodes.



D1: 1N4007 D2: UF4004 D3: 1N4148/1N914 Q1– Q45: 2N6517/MPSA44/MPSA42

NOTE: THE SWITCHMODE INVERTER CIRCUIT (IC9, Q46-Q48, L1 & D2) PRODUCES A VOLTAGE OF 200-220V DC

Parts List

2 double-sided PC boards, code NX14L & NX14U
6 1N14 Nixie tubes
2 NE-2 neon indicators
1 32.768kHz watch crystal
1 200µH 3A inductor (L1)
1 miniature toggle switch (S1)
3 momentary pushbutton switches (S2-S4)
1 2.1mm DC connector (CON1)

Semiconductors

6 4017 decade counter/dividers (IC1-IC6)
1 4060 oscillator/divider (IC7)
1 4013 dual D flipflop (IC8)
1 34063 switchmode controller (IC9)
45 2N6517 high-voltage NPN transistors (Q1-Q45)
1 BC337 NPN transistor (Q46)
1 BC327 PNP transistor (Q47)
1 IRF740 N-channel Mosfet (Q48)
1 1N4007 rectifier diode (D1)
1 UF4004 fast recovery diode (D2)
1 1N914, 1N4148 diode (D3)
1 6.2V 1W zener diode (ZD1)
1 W02/4 bridge rectifier (BR1)
6 blue LEDs (LED1-LED6)

Capacitors

1 1F Supercap
2 1000µF 25V PC electrolytic
1 47µF 25V PC electrolytic
1 4.7µF 450V PC electrolytic
1 100nF MKT polyester
1 47nF MKT polyester
1 1nF MKT polyester
1 100pF ceramic
1 10-40pF trimmer

Resistors (0.25W, 1%)

1 10MΩ	1 12kΩ
1 390kΩ	3 10kΩ
2 330kΩ 1W	2 2.2kΩ
1 220kΩ	4 820Ω
1 82kΩ	1 470Ω
6 68kΩ 1W	2 180Ω
44 27kΩ	1 100Ω
1 22kΩ	

Nixie Tubes: How They Work

Nixies work on the same principle as the simple neon indicator. A neon indicator consists of a small glass tube filled with inert neon gas and containing two metal electrodes. When a sufficiently high voltage is applied between the electrodes, the gas around the negative electrode (the cathode) ionises and envelops the electrode with an orange glow.

The voltage required for ionisation of the gas is dependent on the electrode spacing and the temperature. Typically it is more than 80V for small neon bulbs and more than 150V for average size Nixie tubes. In practice, higher voltages are used, with a series resistor to limit the discharge current to a safe value.

Two small neons are used in this clock design, between the hours and minutes and between the minutes and seconds tubes.

A Nixie tube has a see-through metal mesh anode at the front and 10 different shaped cathodes (0–9) behind the anode, each being terminated to a different wire lead or pin on the tube. The number-shaped cathodes are not necessarily placed in direct order behind the anode but are placed to give minimum obstruction of each digit by the ones in front of it.

The anode is connected to +HT via a current-limiting resistor and the particular cathode is pulled down to 0V when it is to be lit. By the way, "HT" is old-timer talk for "high tension" or high voltage.

From Russia with love

There's another throwback to the sixties with this clock. It uses Russian 1N14 Nixies. The Russians kept making these long after western countries had ceased manufacture, as they were shut out from a lot of new technology from the west during the Cold War.

In turn, each high-voltage transistor is driven from the respective output of a 4017 CMOS counter chip. The counter chips are clocked by a 32.768kHz watch crystal driving a 4060 oscillator/divider chip. Apart from the high voltage DC-DC inverter, that is pretty well all there is to it.

Let's start in the bottom lefthand corner of the circuit, with the power supply section. The whole circuit runs from a standard 12VAC plugpack or it can run from a 12V car battery. Nixie car clock, anyone?

The incoming 12VAC is connected to a full-wave rectifier bridge (BR1) and a 1000µF 25V electrolytic capacitor. The resultant 12-16V DC rail powers a high-voltage SMPS (switchmode power supply) which employs an MC34063 chip (IC9).

A 6.2V zener diode (ZD1) provides a regulated 5.4V supply for all the CMOS chips via diode D1. Also across this supply is the 1 Farad Supercap which can keep the clock "ticking over" for six hours or more during power failures. This is without running the Nixie tubes of course and when power is restored, the Nixies light up with the correct time displayed.

When external power fails or is disconnected, diode D1 isolates the Supercap supply from the other power supply components to avoid their load current.

High-voltage supply

The high-voltage supply consists of the MC34063 switchmode controller chip (already mentioned), together with inductor L1 and a few other components. **It might look quite innocuous but it produces around 220V, enough to give you quite a boot if you touch the wrong parts of the PC boards.**

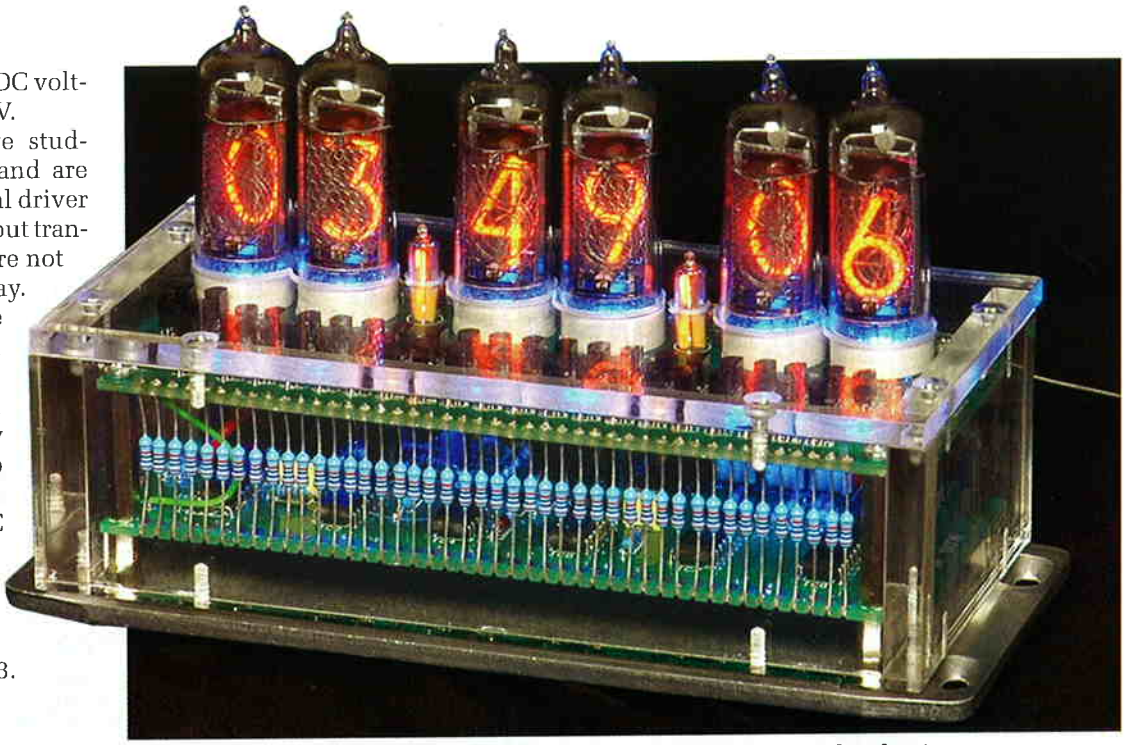
The MC34063 runs at about 40kHz, as set by the 1nF capacitor at pin 3. It drives a pair of complementary transistors, Q46 & Q47, which in turn drive switching Mosfet Q48.

The circuit is a boost or up-converter which works by switching a current at high frequency through inductor L1 and using the stored energy to charge a capacitor via fast recovery diode D2, during the Mosfet off times. A resistive feedback network consisting of the 390kΩ and 2.2kΩ resistors connected

to pin 5 maintains the output DC voltage at between 200V and 220V.

For those who might have studied the MC34063 datasheet and are puzzled by the unconventional driver connections, note that the output transistors within the MC34063 are not connected in the standard way. Instead, they connect the drive waveform to Q46 & Q47 via their "eb-bc" junctions. This odd configuration was found to give the highest efficiency in this high-voltage step-up circuit.

Higher frequency DC-DC converter chips such as those from Maxim were tried but proved to be ultra-sensitive to PC board layout and had higher EMI than the MC34063.



Once again, this night-time photo doesn't do the clock justice. The glowing colours from the Nixie displays and the blue LEDs are actually quite a lot brighter and more dynamic than this photograph shows.

Crystal oscillator

This is the time standard for the clock and it uses a 32.768kHz watch crystal and a 4060 CMOS oscillator-divider (IC7). The crystal is connected via a 2.2kΩ current-limiting resistor while the 10MΩ resistor is there to provide bias for the internal inverter stages. The 100pF capacitor and the 10-40pF trimmer capacitor provide the correct capacitive loading for the crystal and enable very fine adjustment of the frequency, for accurate time keeping.

The output frequency at the final stage of the 4060 (pin 3) is 2Hz. This is fed to the second section of a 4013 dual D flipflop (IC8b) which divides by two to produce 1Hz pulses to operate the clock counter chain.

Time-setting

Time setting is done by three momentary-contact pushbutton switches: S2 (FAST), S3 (SLOW) & S4 (STOP).

When pressed, the STOP button holds the reset pin of IC8b high, via an 820Ω resistor, to stop the count for precise seconds setting.

The SLOW button connects 1Hz pulses from IC8b into the minutes counter (IC4) overriding the tens of seconds counter (IC5) due to the voltage divider action of the 82kΩ and 12kΩ resistors. The FAST button works the same way but connects 8Hz pulses from the 4060 into the same point; ie, pin 14 of IC4.

Main clock counter chain

The clock counter uses six 4017 CMOS decade counter/dividers (IC1-IC6), one for each Nixie tube. The 4017s each have 10 high-going outputs, giving 60 available outputs of which 44 are required to implement the 12-hour clock. Each of these 44 outputs has a 27kΩ resistor to the base of a high-voltage TO92 transistor (Q1-Q44), with each collector connected to the relevant Nixie tube cathode.

Note that these transistors need to have a breakdown voltage rating of at least 300V and those supplied for the clock kit are MPSA42, MPSA44 or 2N6517, all of which were originally designed for TV video amplifier stages.

Clock counting sequence

Now we need to discuss the interconnections of the 4017 decade counter/divider chain to make it count and indicate as a 12-hour clock.

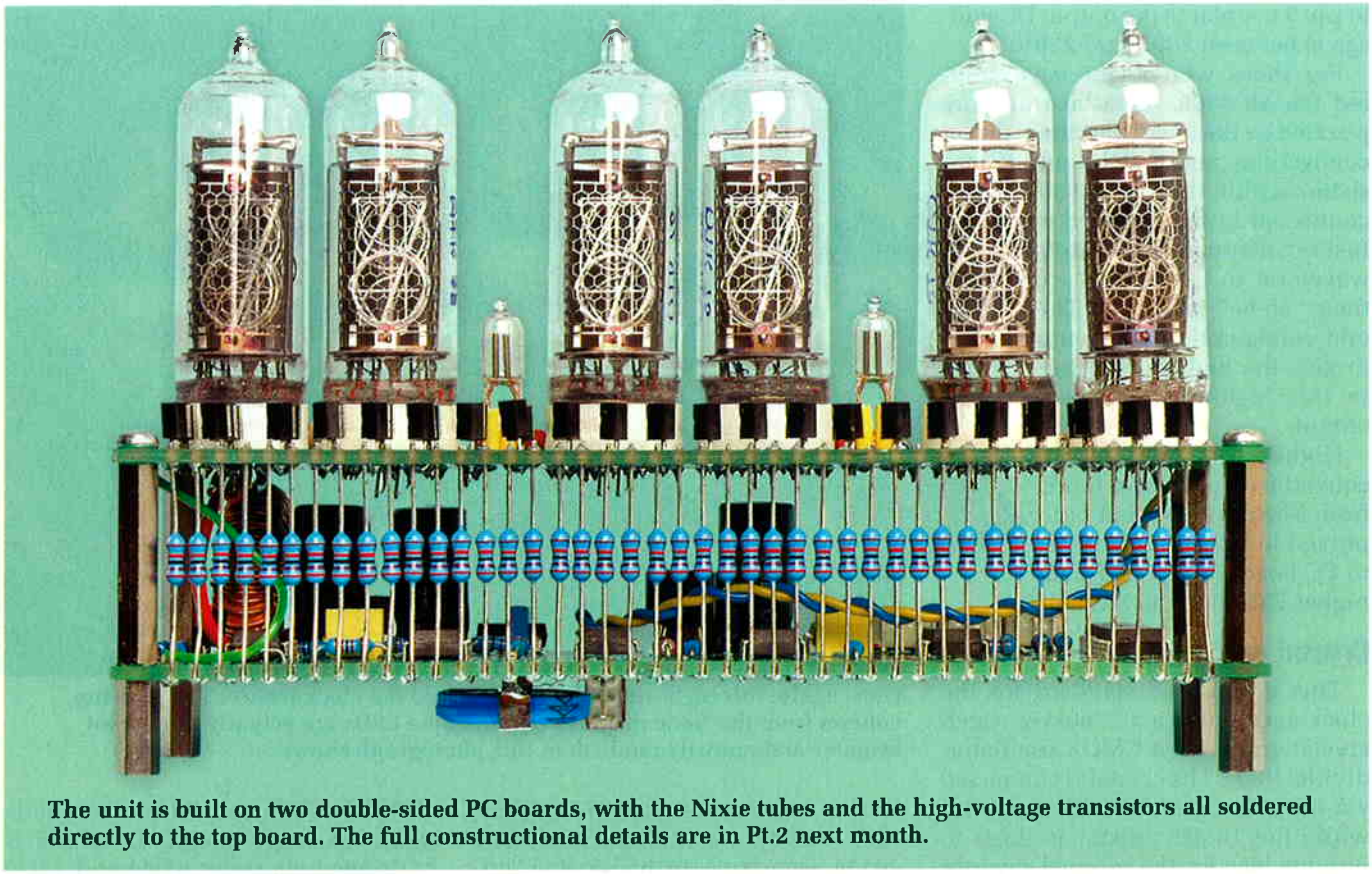
SECONDS STAGE: the 1Hz output from IC8b is connected to the clock input (pin 14) of the seconds counter (IC6), which causes its outputs to go high in turn at 1-second intervals from 0-9. The carry-out output of IC6 (pin 12) is connected to the clock input (pin 14) of the tens of seconds counter (IC5) which has its "6" output connected to the reset (pin 15). It therefore resets itself at the "6" count, thus giving a total seconds count of 59 which is then reset to 00 to start the next minute.

MINUTES STAGE: the tens of seconds carry-out output at pin 12 of IC5 is connected via series 82kΩ and 12kΩ resistors to the clock input (pin 14) of the minutes counter (IC4). Its outputs go high in turn at 1-minute intervals from 0-9 and its carry-out output (pin 12) drives the clock input of the tens of minutes counter (IC3). The tens of minutes counter resets at "6" in the same way as the tens of seconds counter.

The seconds and minutes counters together count to 59 minutes and 59 seconds then reset to 0000, passing the last carry-out to the hours counter (IC2).

HOURS STAGE: the hours counter counts from 0-9 but because the clock must start at 1 o'clock (not 0 o'clock!) the Nixie is wired so that the numerals read 1 for O0, 2 for O2, etc, up to 9 for O8 and then 0 for O9 when the carry-out is passed to the tens of hours counter IC1 to read "1" (the highest readout for a 12-hour clock).

The hours counter (IC2) counts from 0-9 (1-9-0 on the Nixie tube) only when the "1" output of the tens of hours counter (IC1) is low. At the same time, the "2" output will be low, causing D3 to conduct and prevent the resets to pin 15 of IC1 & IC2 from being activated. When the tens of hours counter reaches "2", both hours counters are reset to 00. This results in a reading of



The unit is built on two double-sided PC boards, with the Nixie tubes and the high-voltage transistors all soldered directly to the top board. The full constructional details are in Pt.2 next month.

"12" on the hours Nixie, corresponding to 12.00.00 or 12 o'clock.

If you would prefer not to have the "0" reading on the tens of hours Nixie, you can simply omit transistor Q1 from the PC board.

Two circuit features remain to be described and the first is transistor Q45 which has its collector connected to the emitters of all 44 Nixie cathode driver transistors. Normally, Q1 is biased on from the 12-16V DC rail via a voltage divider consisting of two 10kΩ resistors. While that 12V supply is present, the Nixies are all driven by the 44 high-voltage transistors.

However, during a power failure the 12V DC supply rail collapses and Q45 turns off, so negligible drive current can flow from the 4017 counter outputs to the bases of the 44 high-voltage transistors. This reduces the current drawn by the counters to an absolute minimum and extends the back-up time provided by the 1F Supercap.

The blue LEDs which provide the up-lighting for the Nixie sockets are run in two series groups of three together with 180Ω current limiting resistors. If you want to turn them off (unlikely, we think), S1 does the job.

Mechanical design

This completes the circuit description so now let's have a brief look at the mechanical design of the clock.

In essence, there are two double-sided plated-through hole PC boards which are stacked together and separated by four 25mm hexagonal metal spacers. The lower PC board carries the power supplies, crystal oscillator and all the dividing/counting circuits. The 1 Farad super capacitor is mounted underneath this board, along with four 10mm hexagonal spacers for mounting the whole assembly to the base of the clock housing.

The upper PC board holds the six Nixies and their associated current limiting resistors, the two neon bulbs and their resistors and the 44 high-voltage driver transistors. Provision is also made on this board for the optional up-lighting kit, consisting the six high-intensity 3mm blue LEDs, two current limiting resistors and the light off/on switch S1.

The two boards are connected together by 44 vertical 27kΩ resistors (the base resistors for the high-voltage transistors). The clock can be supplied with either a see-through Perspex case or a white powder-coated diecast aluminium case – see photos.

Next month, we will give the construction details and show how to install the blue LED uplighting. SC

Where To Buy The Parts

(1) Complete NX-14 kit with finished metal baseplate (does ***not*** include housing or blue LED uplighting components): $179.00.
(2) Diecast aluminium housing: $39.00 in plain finish ready for polishing or painting; $45.00 supplied powder coated (shoji white).
(3) Transparent polished Perspex housing: $54.00.
(4) Blue LED uplighting kit: $19.00.
(5) 10V AC plugpack supply: $14.50
(6) Car lighter cable for 12V DC operation: $4.50
Spare 1N14 Nixie tubes: $15.00 ea.
The NX-14 Nixie Clock is also available fully built and tested. Enquiries to: Gless Audio, 7 Lyonsville Ave, Preston, Vic 3072. Phone (03) 9442 3991; 0403 055 374. Email: glesstron@msn.com
Note: the PC board patterns for this project are copyright to Gless Audio.

BOOK REVIEWS

by Leo Simpson

Self on Audio, by Douglas Self.

Second edition, published 2006 by Newnes. ISBN 0 7506 8166 7 Paperback, 232 x 156mm, 468 pages. Price: $83 incl GST.

Anyone who has read our audio amplifier articles over the last 10 years or more will know that we regard Douglas Self very highly.

He is one of the few audio designers in the world who not only has published many articles on his designs but has also submitted them to very critical analysis using the best available measurement equipment such as that made by Audio Precision.

Not for him is the subjective morass of musicality. Instead, he takes the strictly objective approach; everything must be measured, analysed and if possible, improved.

Thus Douglas Self has clearly demonstrated the superiority of bipolar transistors over Mosfets, in terms of linearity at least. That fact alone causes us to applaud but he has been so prolific over a period of at least 30 years that it is great to be able to read a collection of his articles in this reference book. It makes a good companion volume to his Audio Power Amplifier Design Handbook, although it must be said that there is considerable overlap in material between the two books.

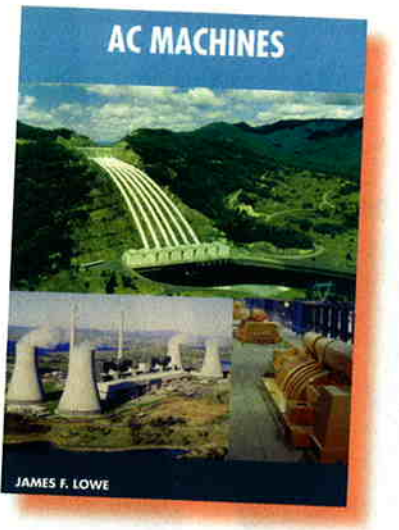
The material which is unique to this book includes articles on various preamplifiers, analog signal switching and a compressor/limiter. All of the articles in this book were originally published in the pages of the British magazine *Wireless World* or as it later became known, *Electronics World*. A list of the featured designs on preamplifiers and related topics includes the following: Advanced Preamplifier Design (November 1976); High Performance Preamplifier (February 1979); Precision Preamplifier (October 1983); Moving Coil Head Amplifiers (December 1987); Precision Preamplifier (July/August/September 1996); Balanced Circuits (April/May 1997); High quality compressor/limiter (December 1975); Inside Mixers (April 1991) and Analog Switching (January/February 2004).

The list of articles on power amplifiers includes the following: Sound Mosfet Design (September 1990): FETS vs BJTs (May 1995); Distortion in Power Amplifiers (eight articles – August 1993 to March 1994); Power amplifier input currents (May 2003); Diagnosing distortions (January 1998); Trimodal audio power amplifier (June/July 1995); Load-invariant audio power (January 1997); Loudspeaker undercurrents (February 1998); Muting relays (July 1999) and Audio power analysis (December 1999).

Some of these articles are now very old but they still provide useful insights and all the articles have a very useful bibliography which can be the source of further research.

All told, this is a most useful reference book and one that we can highly recommend. It is available from the SILICON CHIP bookshop.

AC Machines, by James F. Lowe



Self-published 2006. ISBN 0 9594962 2 X. Paperback 289 x 207mm, 160 pages. Price $66.00 incl GST.

Good basic books on the theory of electric motors are few and far between. This is why we so favourably reviewed the text "Electric Motors & Drives" in the May 2006 issue. This new text is written by an ex-TAFE college teacher to cover the course content of the Australian National Curriculum Subjects, NE10 AC Machines, NE12 Synchronous Machines and the AX part of NE30 Electric Motor Control and Protection. That being the case, it is all relevant and practical material to anyone wanting a good fundamental background on electric motors.

Being written specifically as a textbook, it has more emphasis on motor theory and employs more diagrams and formulas but it is still easy to read and the majority of our readers will find it reasonably easy to digest.

In all, there are 14 chapters split into four sections: Polyphase (ie, 3-phase) Motors; Single Phase Motors; Synchronous Machines and Motor Starting and Control. As indicated by the title, the book makes no reference to DC motors, apart from the section devoted to universal series motors which are used in most electrical appliances.

The first five chapters on polyphase motors are on Electrical Principles, Production of a Rotating Magnetic Field, Induction Motor Construction, Three-Phase Cage-Rotor Motor Characteristics and Three-Phase Wound Rotor Characteristics.

Then there are three chapters devoted to single-phase motors: The Split-Phase Principle, Motors and Capacitors, and Shaded Pole and Universal Motors. These are most useful chapters to anyone who wants to understand how single-phase induction motors can start and run when in fact there is no inherent rotating magnetic field in any single-phase system. More particularly, the section on shaded pole motors is very useful as this topic widely misunderstood.

Four chapters are devoted Synchronous machines: Alternator Fundamentals; Alternator Construction; Alternator Windings and Paralleling and Synchronous Motors. Finally, there are chapters on Polyphase Motor Starters and Polyphase Motor Control and Protection.

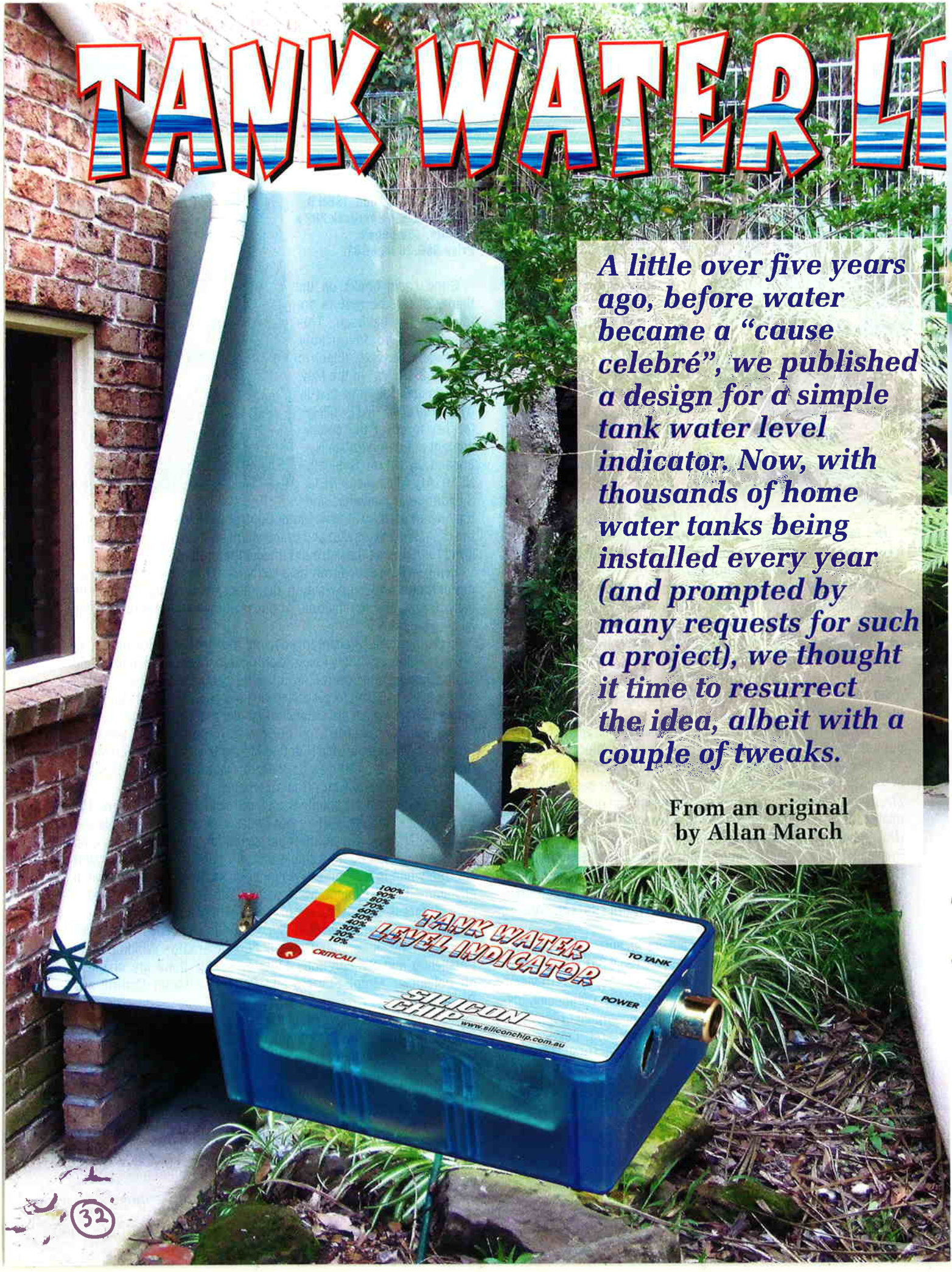
Also included is a section giving the answers to all the self-test questions which follow each chapter. All told, this is a practical down-to-earth text which can be regarded as a very good complement to the "Electric Motors & Drives" text referred to above. Both books are available from the SILICON CHIP Bookshop.

One comment should be added and that is the photos in this text are not of good quality – a remark that could be applied too often to textbooks. These days there is no reason why photos should not be reproduced to a high standard. SC

TANK WATER LE

A little over five years ago, before water became a "cause celebré", we published a design for a simple tank water level indicator. Now, with thousands of home water tanks being installed every year (and prompted by many requests for such a project), we thought it time to resurrect the idea, albeit with a couple of tweaks.

From an original
by Allan March



EVEL INDICATOR

Home water tanks are undoubtedly a good idea. Why pay for water when you can catch it free?

You can have the greenest garden in the street, along with the cleanest car, while you thumb your nose at the water restrictions now in place in most capitals and many regional centres.

But once installed, how can you determine how full (or how empty!) your tank really is?

There are several traditional methods for finding the level of water, among them: (1) tapping down the side of the tank until the sound suddenly changes; (2) on a hot day feeling down the tank for a change in temperature; (3) pouring boiling water down the side of the tank and looking for the line of condensation and (4) removing the tank cover and dipping in a measuring stick.

The first two methods are notoriously unreliable, while the last two also have their problems. Only the last is accurate. But who wants to clamber up on top of a tank each time you want to find out how much water is inside it?

That's where this simple circuit comes in. It uses a row of ten coloured LEDs arranged in a bargraph display to give a clear indication of how the water supply is holding up. The more LEDs that light, the higher the water in the tank.

The LEDs are arranged in the familiar "traffic light" colours of green, yellow and red to instantly indicate relative levels at a glance (green is good, yellow not so good and red is bad!) as well as the specific levels represented by the individual LEDs.

A further red LED lights when the tank level drops below a critical threshold. This can simply be to warn you of impending localised drought (hey, your tank's empty!) – or it (or indeed any of the ten-LED "string") could be used to trigger an audible alarm, turn on a pump etc, as we will discuss later.

There are no fancy microcontrollers or digital displays used in this project. Instead, it uses just a handful of common parts to keep the cost as low as possible.

It can be used in a traditional metal tank or one of the new slimline plastic jobs. As long as you can get very access inside the tank from the top to the bottom, this circuit will work.

Circuit description

Fig.1 shows the circuit, which only has a few differences to the April 2002 circuit. As in that design, it is based on an LM3914 linear LED dot/bar display driver (IC1) which in this case drives not five but ten LEDs (LEDs 1-10).

Pin 9 of the LM3914 is tied high so that the display is in bargraph mode and the height of the LED column indicates the level of the water in the tank. However, (and this is one of the minor tweaks we've made), this pin can be easily isolated, turning the display into a dot type, thus saving power. If you're running from a battery supply in the bush, often every milliamp is sacred!

Indeed, the PC board pattern has been arranged so that a miniature switch could be included to swap between bar and dot modes.

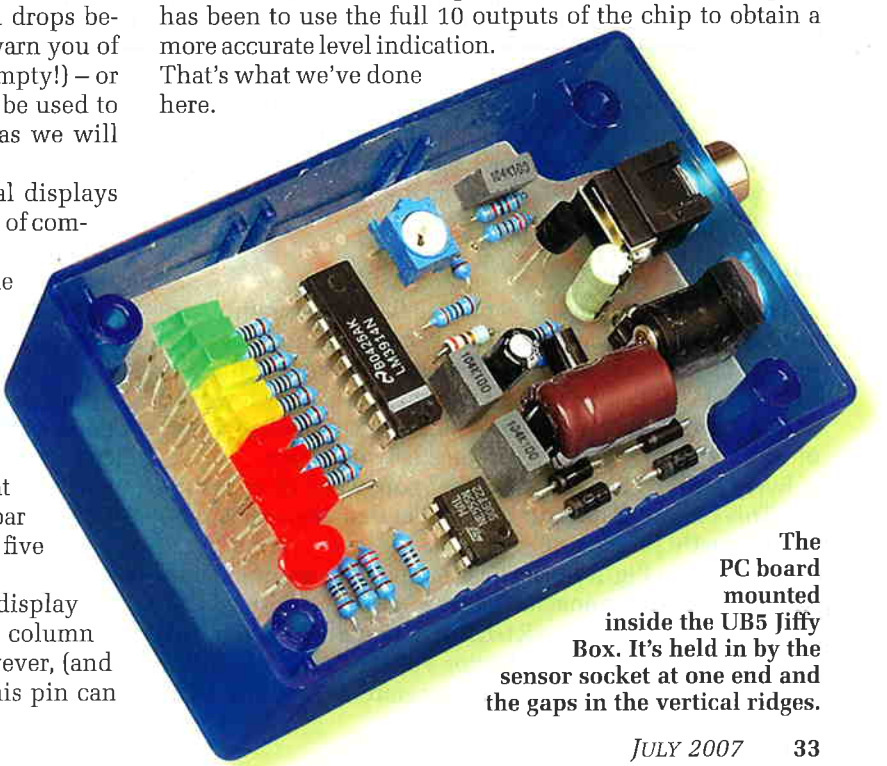
The full-scale range of the bargraph depends on the voltage on pin 6. This voltage can be varied using VR1 from about 1.61V to 2.36V. After taking into account the voltage across the 390Ω resistor on pin 4, this gives a full-scale range that can be varied (using VR1) between about 1.1V (VR1 set to 0Ω) and 2V (VR1 set to 470Ω).

By the way, if you're wondering where all the above voltages came from, just remember that IC1 has an internal voltage reference that maintains 1.25V between pins 7 & 8. This lets us calculate the current through VR1 and its series 1kΩ resistor and since this same current also flows through the series 1.5kΩ and 390Ω resistors, we can calculate the voltages on pins 6 and 4.

As well as setting the full-scale range of the bargraph, VR1 also adjusts the brightness of LEDs 1-10 over a small range. However, this is only a secondary effect – it's the full-scale range that's important here.

IC1's outputs directly drive LEDs 1-10 via 1kΩ current limiting resistors.

If you recall the original circuit, it had only five LEDs, all the same colour (green), to show water level . Changing the LED colours was no problem but a common request has been to use the full 10 outputs of the chip to obtain a more accurate level indication. That's what we've done here.



The PC board mounted inside the UB5 Jiffy Box. It's held in by the sensor socket at one end and the gaps in the vertical ridges.

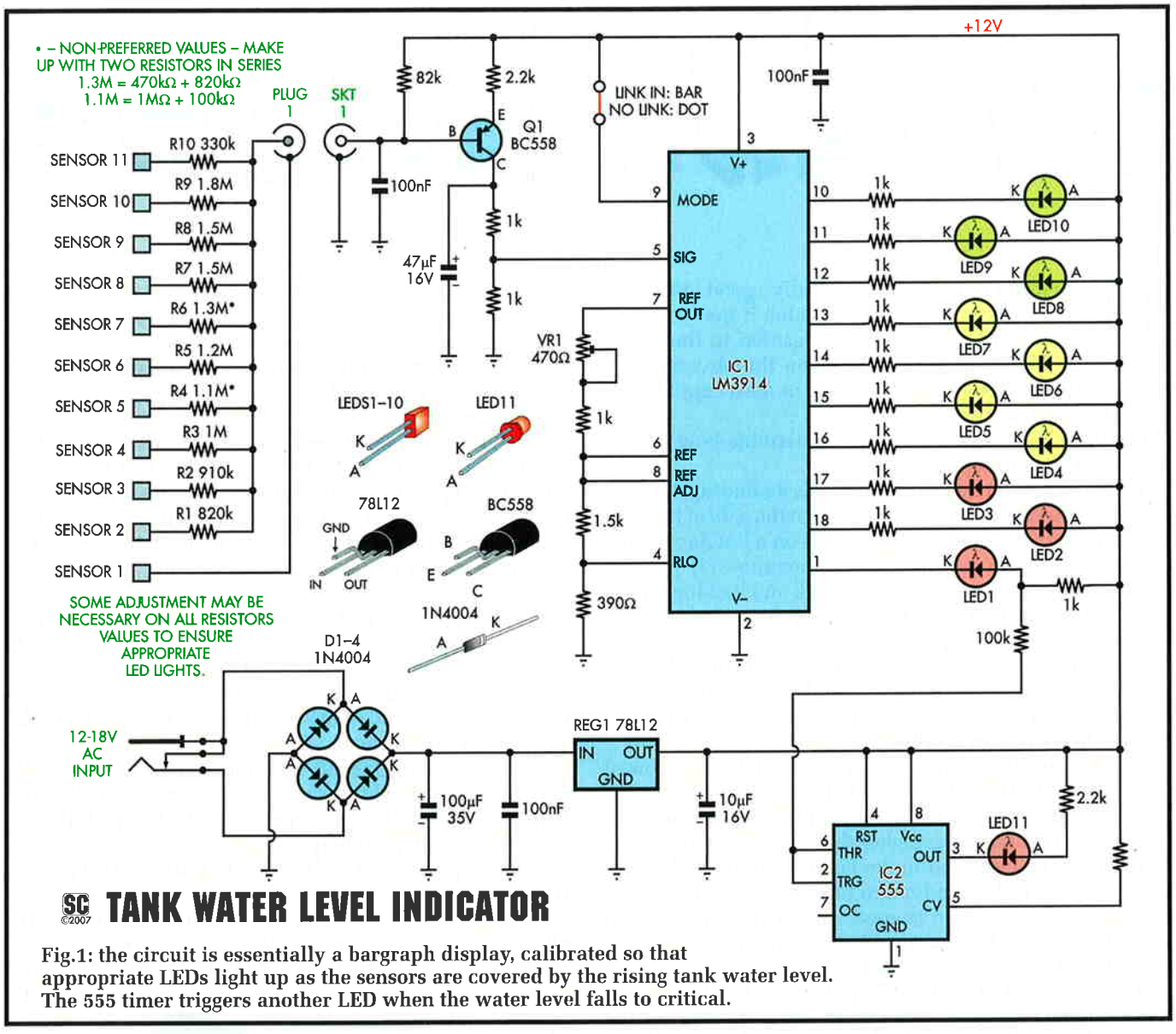


Fig.1: the circuit is essentially a bargraph display, calibrated so that appropriate LEDs light up as the sensors are covered by the rising tank water level. The 555 timer triggers another LED when the water level falls to critical.

If you *do* only need five levels, you could omit LEDs 2, 4, 6, 8 and 10 and tie pin 11 to pin 10, 13 to 12, 15 to 14, 17 to 16 and 1 to 18 – as per the original 2002 circuit. In this case we'd use two green, one yellow and two red LEDs in the bargraph.

Water level sensor

The input signal for IC1 is provided by an assembly consisting of 11 sensors located in the water tank and connected to the indicator unit via light-duty figure-8 cable. This sensor assembly relies on the fact that there is a fairly low (and constant) resistance between a pair of electrodes in a tank of water, regardless of the distance between them.

Every school child is taught that pure water is an insulator. This circuit demonstrates the fact that even rain water is not exactly pure!

As shown in Fig.1, sensor 1 is connected to ground, while sensors 2-10 are connected in parallel to the base of PNP transistor Q1 via resistors R1-R10. Q1 functions as an inverting buffer stage and its collector voltage varies according to how many sensor resistors are in-circuit (ie, how many sensors are covered by water).

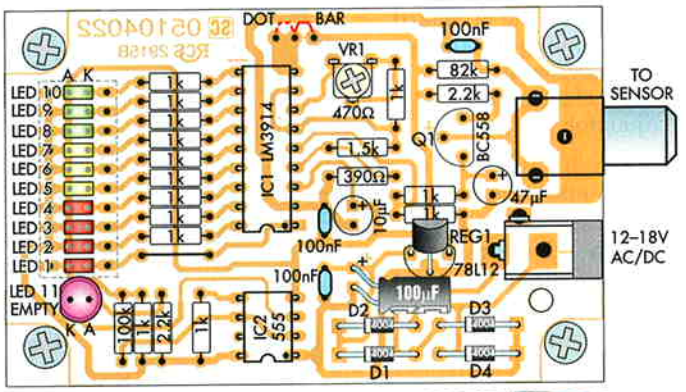
When the water level is below sensor 2, resistors R1-R10 are out of circuit and so Q1's base is pulled high by an 82kΩ resistor. As a result, Q1 is off and no signal is applied to IC1 (therefore, LEDs 1-10 are off).

However, if the water covers sensor 2, the sensor end of resistor R1 is essentially connected to ground. This resistor and the 82kΩ resistor now form a voltage divider and so about 9.6V is applied to Q1's base.

As a result, Q1's emitter is now at about 10.2V which means that 0.8mA flows through the 2.2kΩ emitter resistor. Because this same current also flows through the two 1kΩ collector load resistors, we now get about 0.8V DC applied to pin 5 (SIG) of IC1. This causes pins 1 of IC1 to switch low and so the first red LED (LED1) in the bargraph lights.

As each successive sensor is covered by water, an additional resistor is switched in parallel with R1 and Q1's base is pulled lower and lower.

As a result, Q1 turns on "harder" with each step (ie, its collector current increases) and so the signal voltage on pin 5 of IC1 increases accordingly. IC1 thus progressively



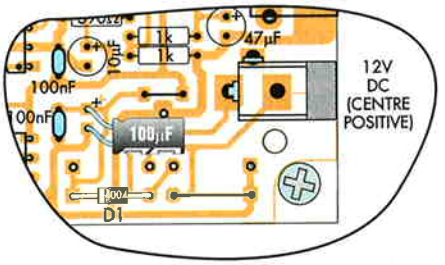
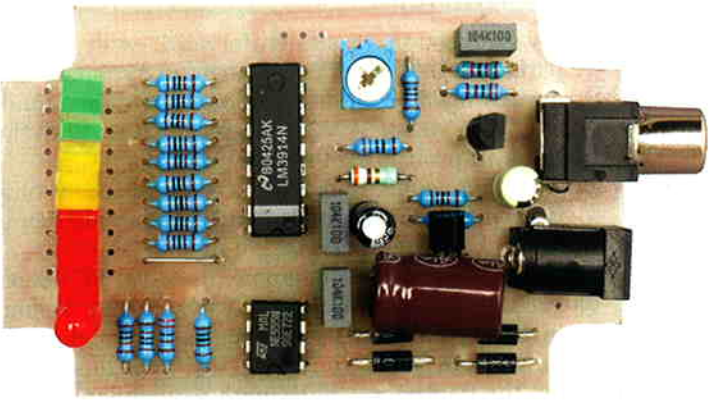


Fig.2: the PC board component overlay with matching photo alongside. Note the "laid over" regulator and filter capacitor. Fig.3, right, is the relevant section of the PC board revised for 12V DC operation.



switches more outputs low to light additional LEDs.

Note that Q1 is necessary to provide a reasonably low-impedance drive into pin 5 (SIG) of IC1, while keeping the current through the water sensors below the level at which electrolysis becomes a problem.

Critical level indication

IC2 is a 555 timer IC and it drives LED11 (a 5mm round type to be obviously different) to provide a warning when the water level falls below the lowest sensing point; ie, when all the other LEDs have been extinguished.

However, in this role, IC2 isn't used as a timer. Instead, it's wired as a threshold detector and simply switches its output at pin 3 high or low in response to a signal on its threshold and trigger inputs (pins 6 & 2).

It works like this: normally, when there is water in the tank, LED1 is on and its cathode is low. This pulls pins 6 & 2 of IC2 low via a 100kΩ resistor, so that these two pins sit below the lower threshold voltage. As a result, the pin 3 output of IC2 is high and LED11 is off.

However, if the water level falls below sensor 2, LED1 turns off and its cathode "jumps" to near +12V. This exceeds the upper threshold voltage of IC2 and so pin 3 switches low and LED11 turns on to give the critical low-level warning.

As the control pin (pin 5) of IC2 is tied to the positive supply rail via a 1kΩ resistor, it will switch at thresholds of $0.46V_{CC}$ (5.5V) and $0.92V_{CC}$ (11V) instead of the usual 555 thresholds of $1/3V_{CC}$ and $2/3V_{CC}$. This is necessary to ensure that IC2 switches correctly to control LED11.

Power sources

Power for the unit is normally derived from a 12VAC plugpack supply. This drives a bridge rectifier D1-D4 whose output (nominally about 17V) is then filtered using a 100µF 35V electrolytic capacitor. This is applied to a 12V 3-terminal regulator (REG1). The 12V output from REG1 is then filtered using a 10µF electrolytic capacitor.

Another change to the 2002 design is the inclusion of 100nF capacitors in parallel with the electros to prevent oscillation. Provision was made for these on the original PC board but were not specified. For the cost of a couple of capacitors, we think it's cheap insurance.

The reason a regulated supply rail is used is to ensure that the water level indication doesn't change due to supply variations.

Having said that, the circuit is just as happy being powered from 12VDC, eg in a mobile home or caravan, or even a solar-backed battery supply in the bush.

A 12V supply with centre positive can be plugged into the power socket. In this case, regulator REG1 and diodes D2, D3 & D4 can be omitted. Both D4 and REG1 are then replaced by wire links – ie, install a link instead of D4 and install a link between the IN & OUT terminals of REG1. These changes are shown in Fig.3.

D1 should remain in circuit to protect against reverse battery connection. Or at the expense of another half volt or so (which shouldn't cause any problems), D1-D4 can be left in situ and then it won't matter which polarity the power connector uses. REG1 is still omitted in this case.

Also, with a known 12V supply (ie, one which doesn't rise markedly above 12V), the 100µF capacitor can be changed to a cheaper (and smaller) 16V type.

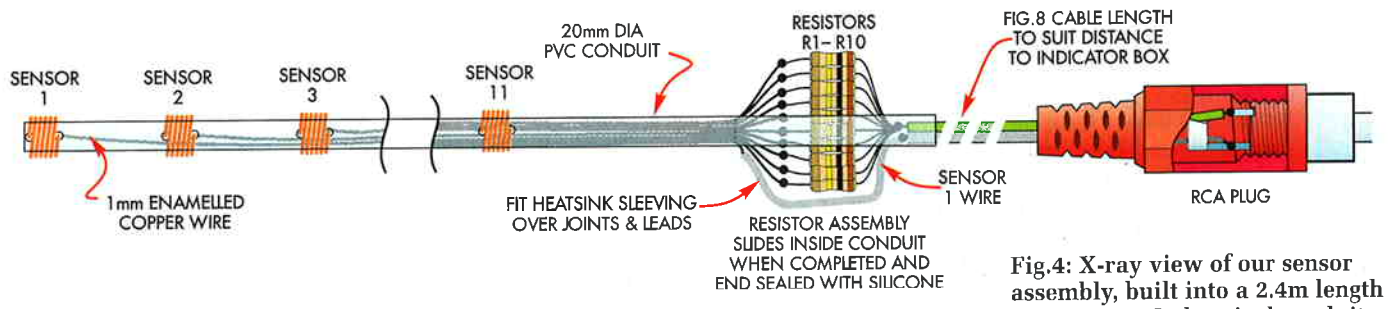

SENSOR 1
SENSOR 2
SENSOR 3
SENSOR 11
20mm DIA PVC CONDUIT
RESISTORS R1–R10
FIG.8 CABLE LENGTH TO SUIT DISTANCE TO INDICATOR BOX
1mm ENAMELLED COPPER WIRE
FIT HEATSINK SLEEVING OVER JOINTS & LEADS
RESISTOR ASSEMBLY SLIDES INSIDE CONDUIT WHEN COMPLETED AND END SEALED WITH SILICONE
SENSOR 1 WIRE
RCA PLUG

Fig.4: X-ray view of our sensor assembly, built into a 2.4m length of 20mm PVC electrical conduit.

Here's the sensor assembly, built on a 2.4m length of 20mm PVC electrical conduit. Each "sensor" (250mm of bared 1mm enamelled copper wire wound around the conduit) is spaced 200mm apart. A drop of glue on the end of each wire would hold the "coil" tight but be careful not to cover too much bare wire with glue! The wires emerge at the top of the conduit to their respective resistors. The copper wire sensors should last a long time in the relatively pure tank water.

Construction

Construction is straightforward, with all the parts installed on a PC board coded 05104022 and measuring 80 x 50mm. This is installed in a standard "UB5" (83 x 54 x 31mm) plastic case, with the LEDs all protruding through the lid.

We happened to use one of the translucent blue types (because they look spiffy!) but they also come in black, grey and clear.

Before fitting any components to the PC board, you'll probably need to modify it by cutting the four inwards-rounded corners which accommodate the pillars in the case. The easiest way to do this is drill out the four corner holes with a much larger drill (say 8mm) then cutting from each of the edges of the board to the hole edges.

We also found that our PC board was slightly oversize (by perhaps 2mm) to fit into the plastic case but a couple of minutes with a file soon took care of that. Check to see that your board is a neat (friction) fit in the top of the case. Don't worry about the holes for the power and sensor plugs – we'll do those later.

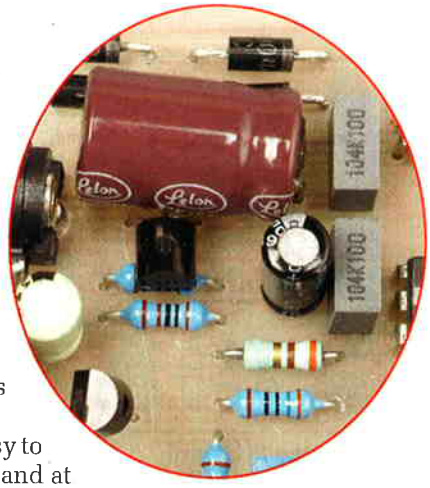
Fig.2 shows the parts layout on the PC board. Begin the assembly by installing the resistors (and the single link at the bottom of the LED resistors connected to LED10), diodes and capacitors (with the exception of the 100µF electro), then install transistor Q1 and the ICs (but not the regulator). Make sure that the diodes and ICs are installed the right way around. The same applies to the electrolytic capacitors – be sure to install each one with its positive lead oriented as shown in Fig.2.

While the circuit calls for a 100µF 35V electro as the main smoothing capacitor, these are now fairly hard to get and you may be forced to use a physically larger 100µF, 50V instead.

The only way this is going to fit (and allow the LEDs to poke through the case lid) is to lay it on its side. This, in turn, means that the 3-terminal regulator (REG1) also needs to be installed almost flat with its legs under the capacitor (you can see what we mean from the photos).

Trimpot VR1 can now be installed, followed by the RCA socket and the 2.5mm power socket. The two sockets are both PC-mounting types and mount directly on the board.

The LEDs are fitted last and must be installed so that the top of each LED is 15mm above the PC board. This ensures that the LEDs all just protrude through the lid when the board is mounted in the case. Make sure that all LEDs are correctly oriented – the anode lead is the longer of the two. Note that there are four holes provided for each the LEDs – you need to use the innermost pairs of holes.



Close-up of the PC board area showing the "lent-over" regulator and 100µF electrolytic capacitor.

It's not particularly easy to get ten LEDs all aligned and at the same height. We cheated a bit by sticky-taping the reds, greens and yellows together as sets, aligning those three sets and then soldering them in. The pads on the board are arguably a little close together to fit standard rectangular LEDs without splaying their legs a little but they can be made to look good!

Dot operation

As mentioned earlier, you can easily convert the LM3914 (IC1) from bar to dot operation if that's what you prefer. All you have to do is cut the thinned section of track between two pads immediately above and to the left of the trimpot.

If you want to get really clever, a miniature single pole, two position switch can be installed in place of the cut link (ie, between the two pads) so you can switch between bar and dot modes at will. This can be arranged so that it emerges through the case lid.

Checking it out

If a visual check confirms that you have all components in the right way and there are no solder bridges or dry joints, set the pot to mid way and plug in the power lead. If all is OK, the "tank empty" LED should light but all the others should remain unlit.

If the reverse happens, adjust the pot so that the "tank empty" LED lights and all others are off.

Now lick your finger and press hard on the two solder joints (ie under the PC board) of the sensor connect or, CON1 – the sensor connector. You should be rewarded with one or more lit LEDs in the string (with the "tank empty" LED going out). The harder you press, the more LEDs should come on. You are, of course, simulating the resistor sensor string with your wet finger. The harder you press, the lower the resistance – and the more LEDs will light.

Final assembly

The PC board is designed to snap into the purpose-designed locators in the vertical ridges on the side of the case. However, first you need to drill two holes in one end of the case, so that they line up with the RCA socket and the power socket when the board is installed (see Fig.6).

You should only introduce the PC board to these holes and the ridge gaps after the PC board is working properly and set up because once in, it's very difficult to get out again!

There is one 5mm hole to be drilled here (for the "tank empty" LED), along with a slot 25 x 5mm for the ten bargraph LEDs. The front-panel artwork (Fig.6) can be photocopied and glued to the case lid.

Sensor assembly

The sensor assembly is made by threading ten lengths of 1mm enamelled copper wire through 20mm OD PVC electrical conduit – see Fig.4. This conduit should be long enough to reach the bottom of the tank, with sufficient left over to fasten the top end securely. The reason for using 1mm wire is primarily to make it easy to thread it through the conduit. Unfortunately, a single 100g roll isn't quite enough for all ten sensors: you'll need part of a second roll.

The top sensor (S10) is placed about 100-150mm below the overflow outlet at the top of the tank, while the other sensors are spaced evenly down the tube.

The distance apart is entirely up to you – depending on how accurate you want the readout and also, of course, the height of your tank.

Begin by using a 1.5mm drill to drill holes through the tube wall at the appropriate points, including a hole for the bottom sensor (S1) to hold it in place securely. The holes should be angled up slightly to convince the 1mm wire that this is the direction to head during the next step.

That done, you can thread the wires through by pushing them through the drilled holes and then up the tube. The end of each wire should also be smoothed before pushing it into the tube, to avoid scratching the enamel of the wires already in the tube. Leave about 250mm of wire on the outside of the tube at each point.

It's a good idea to trim each successive wire so that it protrudes say 20mm further out of the top of the tube than its predecessor. This will allow you to later identify the individual wires when attaching the resistors.

When all 11 wires have been installed, the next step is to solder the wire for S1 to the "earthy" side of the figure-8 lead, cover it with insulating sleeving and pull the covered joint down about 50mm into the 8mm tube. This done, the resistors can be soldered to their appropriate wires.

Push about 15mm of 2.5mm sleeving over each wire before attaching its resistor. This sleeving should then pulled up over the joint and the bottom end of each resistor after it is soldered. Once all the resistors have been soldered, the wires should be pulled down so that the joints are just inside the tube, as shown in the photo.

When this process is complete, there will be ten resistors protruding from the top of the conduit. Their remaining leads are then twisted together, soldered to the other side of the figure-8 cable and covered with heatshrink tubing.

The other end of the figure-8 cable is fitted with an RCA plug, with the resistor lead going to the centre pin and the sensor 1 lead going to the earth side of the connector.

The next step is to scrape away the enamel from the 150mm wire lengths at each sensor point and wind them firmly around the outside of the tube. A 30mm length of 20mm copper water pipe can be pushed over sensor 1 to add weight and increase the surface area if desired.

On no account should solder be used on the submerged part because corrosion will result from galvanic action.

Finally, the end of the plastic conduit and the holes can

Parts List – Tank Water Level Indicator

1 PC board, code 05104022, 80 x 50mm
1 UB5 plastic case, 83 x 54 x 31mm
1 PC-mount RCA socket
1 RCA plug
1 PC-mount 2.5mm power socket
1 12V AC 500mA plugpack
2 100g spools 1.0mm enamelled copper wire
1 length (to suit) 20mm-OD PVC electrical conduit

Semiconductors
1 LM3914 linear dot/bar driver (IC1)
1 NE555 timer (IC2)
1 BC558 PNP transistor (Q1)
1 78L12 12V regulator (REG1)
4 1N4004 diodes (D1-D4)
4 rectangular red LEDs (LEDs1-4)
3 rectangular yellow LEDs (LEDs5-7)
4 rectangular green LEDs (LEDs8-10)
1 5mm red LED (LED11)

Capacitors
1 100µF 35V PC electrolytic
1 47µF 16V PC electrolytic
1 10µF 16V PC electrolytic
3 100nF MKT polyester

Resistors (0.25W, 1%)

1 1.8MΩ	2 1.5MΩ	1 1.2MΩ	2 1MΩ
1 910kΩ	2 820kΩ	1 470kΩ	1 330kΩ
2 100kΩ	1 82kΩ	2 2.2kΩ	1 1.5kΩ
14 1kΩ	1 390Ω		

1 470Ω trimpot

Miscellaneous
Light-duty figure-8 cable, 2.5mm PVC sleeving, heatshrink tubing.

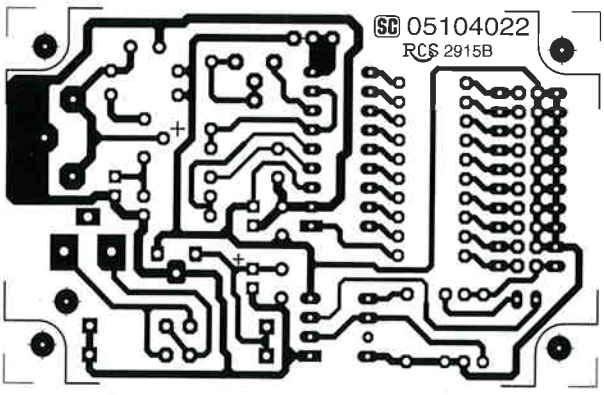


Fig.5: full size PC board artwork. This was adapted from the original (April 2002) PC board by Bob Barnes of RCS Radio

Fig.6: front panel artwork. A photocopy of this may be used as a drilling template for the front panel.

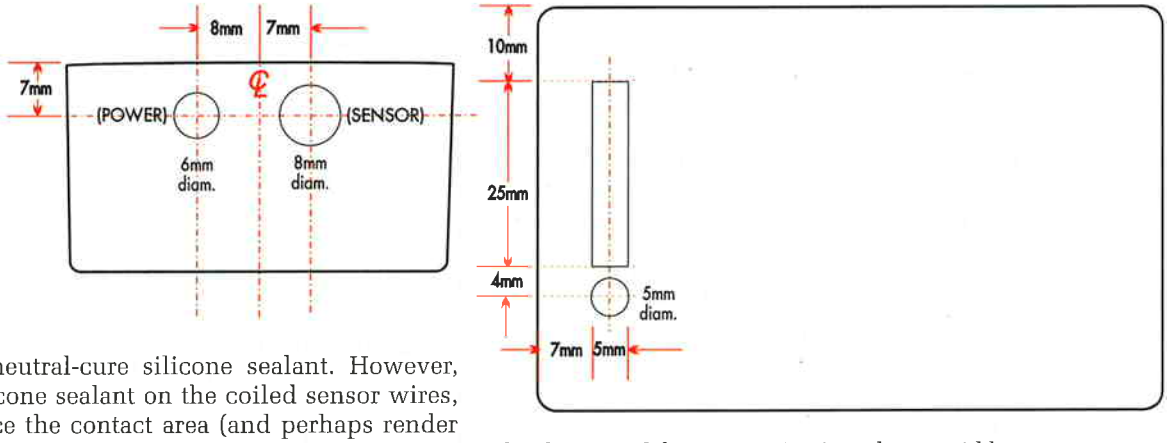


Fig.7: drilling detail for the box end (right) and box lid (far right). The slot can be made by drilling a row of 4.5mm holes down the centreline and enlarging with a small file.

be sealed with neutral-cure silicone sealant. However, don't get any silicone sealant on the coiled sensor wires, as this will reduce the contact area (and perhaps render them ineffective).

Switching on

Now for the big test. Apply power to the unit and check that the red "tank empty" LED comes on and that there is +12V on pin 3 of IC1. If all is well, the unit can now be tested by connecting the sensor assembly and progressively immersing it (starting with sensor 1) in a large container full of water (we used a swimming pool). When sensor 1 and sensor 2 are immersed, LED1 should extinguish and LED2 should come on.

Similarly, when sensors 1, 2 & 3 are immersed, LEDs 1-5 should be on and so on until all LEDs are lit.

Finally, trimpot VR1 must be set so that the appropriate LEDs light as the sensors are progressively immersed in water. In practice, you should find the two extremes of the pot range over which the circuit functions correctly, then set the pot midway between these two settings.

Using it on metal tanks

If the tank is of made of metal, you can dispense with Sensor 1 and connect the tank directly to the circuit ground. You must also ensure sensors 2-10 do not touch the walls of the tank. This can be done by slipping a length of 25mm-OD PVC conduit over the completed probe, securing it at the top so that the water inside can follow the level in the tank.

Controlling other devices

You could use this project to control something external – for example, a pump to refill the tank from a larger storage tank or reservoir, a siren or warning alarm, perhaps trigger a radio link to remotely warn, and so on. Provision has been made on the PC board for this: you will note that each of the LEDs, with the exception of the "critical level" LED has another pair of pads associated with it – these are intended to connect to external circuitry.

The reason the "critical level" LED has no extra pads is not simply lack of space – we would imagine that any action you wanted to take would have happened long before the water level reached that critical point.

However, if you really wanted to, this level could also be used as outlined here for the rest of the LEDs – it's just that you'd have to arrange connections yourself.

As the LM3914 outputs go low to turn on their LEDs, these could also switch on a PNP transistor (with suitable current limiting resistors), leaving the LEDs in place. That transistor could be used to switch, say, a relay to control whatever you wished.

You could also switch an opto-coupler, such as a 4N28, in parallel with the LEDs, itself perhaps switching a relay. With due care to power wiring, a Triac optocoupler might be used instead.

Solid-state relays are also an option, providing you can get one which operates when its input is taken low. Of course, a transistor could invert the LM3914 output for you.

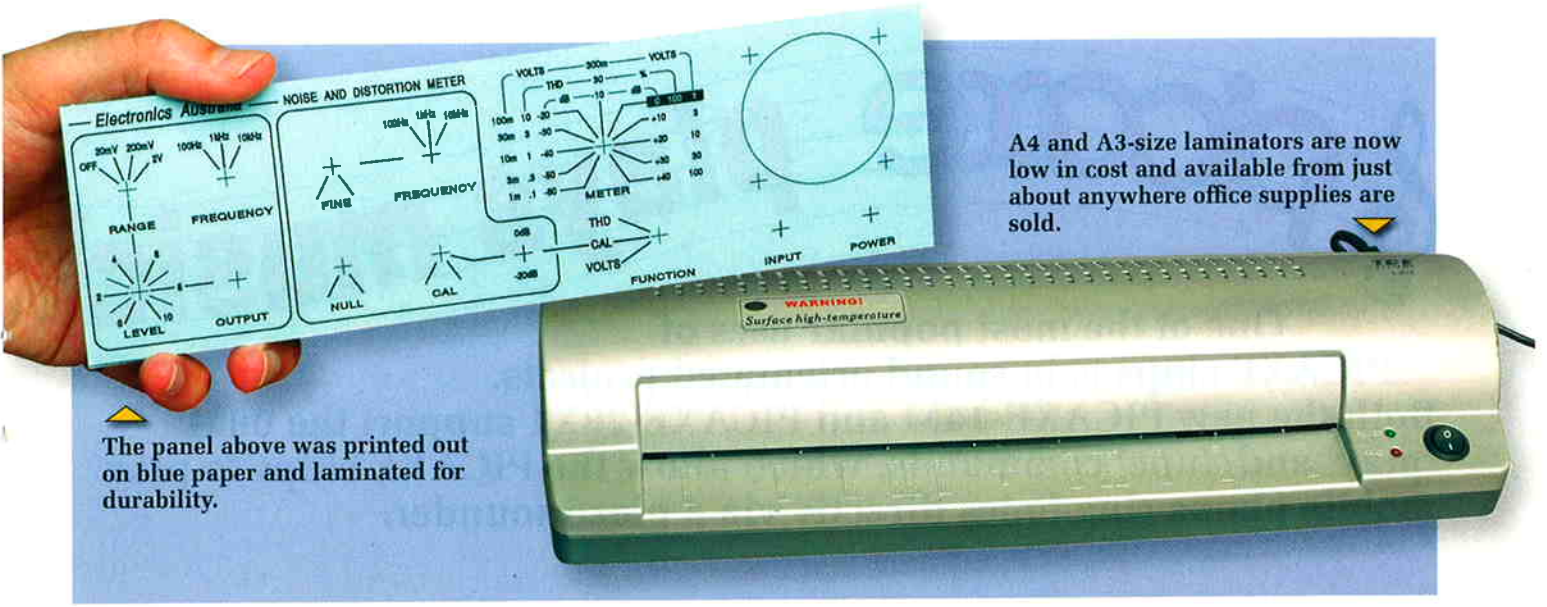
Regardless of what you are controlling, you MUST take into account the following:

- Get your project working as described (ie, stick to low voltage!) before attempting to interface it to anything.
- Anything switching or controlling mains voltages must be more-than-adequately insulated, with cable clamps to prevent broken leads contacting anything else.
- Ensure that any relays, etc, you use are rated for both the voltage and the current of the device being controlled. Bear in mind that pump motors, for example, usually have a significantly higher starting current than running current.
- If in doubt, don't!

SC

Resistor Colour Codes

No.	Value	4-Band Code (1%)	5-Band Code (1%)
1	1.8MΩ	brown grey green brown	brown grey black yellow brown
2	1.5MΩ	brown green green brown	brown green black yellow brown
1	1.2MΩ	brown red green brown	brown red black yellow brown
2	1MΩ	brown black green brown	brown black black yellow brown
1	910kΩ	white brown yellow brown	white brown black orange brown
2	820kΩ	grey red yellow brown	grey red black orange brown
1	470kΩ	yellow violet yellow brown	yellow violet black orange brown
1	330kΩ	orange orange yellow brown	orange orange black orange brown
2	100kΩ	brown black yellow brown	brown black black orange brown
1	82kΩ	grey red orange brown	grey red black red brown
2	2.2kΩ	red red red brown	red red black brown brown
1	1.5kΩ	brown green red brown	brown green black brown brown
14	1kΩ	brown black red brown	brown black black brown brown
1	390Ω	orange white brown brown	orange white black black brown



The panel above was printed out on blue paper and laminated for durability.

A4 and A3-size laminators are now low in cost and available from just about anywhere office supplies are sold.

Making Panels For Projects

While it's easy enough to source all of the bits 'n' pieces for the projects described in SILICON CHIP, labelling for the front/rear panels can be a real problem. Sure, a neat printing job with a permanent marker can be functional but it doesn't look very professional. Besides, what if you want to add graphics?

By PETER SMITH

THE QUICKEST AND EASIEST way to produce front-panel labels for our projects is to make use of the original artwork published in the magazine or posted on our website. Magazine artwork can be photocopied and then laminated. For even better results, try scanning in the artwork (or printing the EPS version from our website) onto good quality inkjet paper. Again, lamination can be used for lasting protection.

John Wark's guide

In fact, John Wark recently wrote in with a seven-step guide to producing top-quality results using lamination. His steps are as follows:

(1). Make two copies of the artwork, one in colour (or on coloured paper) if desired. Note that the use of standard 80gsm paper and the lamination material specified below will allow the completed panel to fit in the slot of typical instrument cases.

(2). Trim the copies to suit the size of the panel and glue the monochrome copy to the panel using water-soluble glue (a "Glu-Stik" works well).

(3). Drill the panel using the label as a template. Small pilot holes should be drilled initially to ensure accuracy. A tapered reamer can be used to enlarge holes in soft materials such as plastic and aluminium.

(4). Remove the paper template by washing under a tap. Be sure to remove all traces of the glue.

(5). Laminate the remaining copy using an 80 micron sleeve and trim to size.

(6). Apply a very thin coating of gel type contact cement to the surface of the panel. If the panel is removable and has rough and smooth sides, choose the rough side. Apply the label to the panel, taking care to get good alignment and smoothing out as necessary.

(7). Allow time for the contact cement to cure and then cut out any holes using a small-bläded craft knife.

John's method is long lasting, looks good and is cheap. However, other methods are available if you don't like the lamination approach.

Scotchmark Laser Labelling

Good results can also be obtained using the "Scotchmark" laser labelling system. Silver and white polyester sheets are available from Wiltronics Research at **www.wiltronics.com.au/catalogue/shop.php?cid=262**. They also have over-laminates that don't require a special applicator.

Yet another method is described in the April 2002 issue of SILICON CHIP, where we demonstrate how to use the 3-part "Quick-Mark" system from Computronics (see **www.computronics.com.au/quickmark**). Back issues are available from our subscriptions department – see the subscription page for details.

We're often asked what graphics package is suitable for creating custom labels. We use CorelDRAW, but virtually any graphics package that allows you to work in physical dimensions (mm) would be suitable. **SC**

PICAXE plays music!

One of the most popular uses of PICAXE chips is in sound orientated projects. Both the new PICAXE-14M and PICAXE-28X1 support the 08M 'play' and 'tune' commands, which allow the PICAXE chips to play mobile phone ring-tones directly via a piezo sounder.

by CLIVE SEAGER (www.rev-ed.co.uk)

But what if you want to play real songs or sounds? The most obvious answer is to record your sound as an MP3 file and play it from the PICAXE chip.

Unfortunately, though, MP3 files are very large and *no* microcontroller, PICAXE included, has sufficient memory to store many files.

Fortunately a company called FDTI (www.ftdichip.com), based in Glasgow, Scotland has produced a very neat 'VMUSIC2' module ideal for this type of application.

The VMUSIC2 module

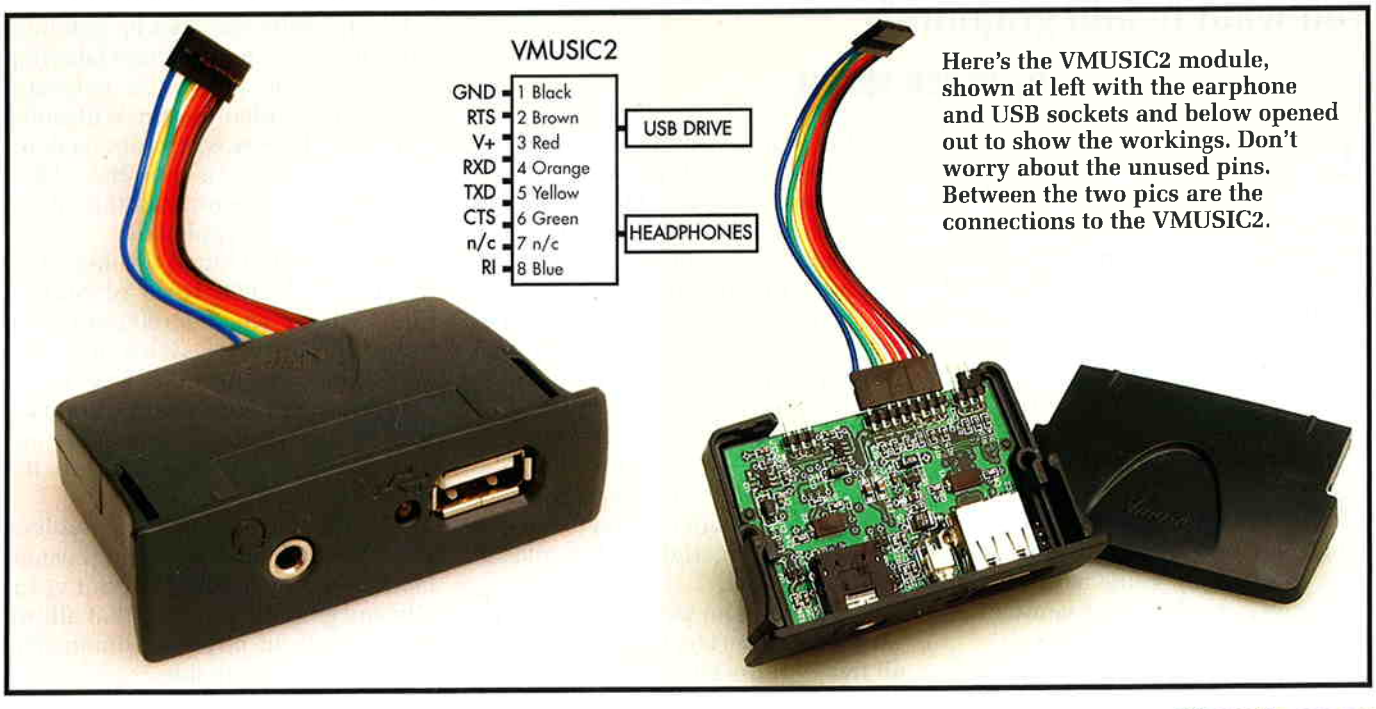
The FTDI VMUSIC2 module is shown below. It is supplied in a neat plastic enclosure but this is very easy to pop open if you want to look inside! The enclosure has a bi-colour LED, a headphone socket and USB thumb drive socket on the front, while on the rear there's an 8 wire connector to connect power and control signals.

Pop open the enclosure and you will find two main components on the PC board - a Vinculum VCN1L USB host controller IC and a VS1003 MP3 playback IC.

In simple terms, MP3 files are read from a USB thumb drive by the VCN1L USB controller and then decoded and played back via the VS1003 chip. The VS1003 sound output line will drive headphones directly; we also used the external speakers from our computer for testing purposes.

It can also drive most amplifiers if you want some real sound!

So to use the system, all we need to do is download a few MP3 (or WAV)



Here's the VMUSIC2 module, shown at left with the earphone and USB sockets and below opened out to show the workings. Don't worry about the unused pins. Between the two pics are the connections to the VMUSIC2.

files from a computer onto a USB 'thumb drive', move the thumb drive to the VMUSIC2 module and then use the PICAXE chip to send play/stop etc commands to the VMUSIC2 module.

VMUSIC2 Connections

The VMUSIC2 is supplied with a colour-coded 8-wire connector. Unfortunately this is on a 2mm (not 2.54mm) pitch and so will not easily connect to stripboard or breadboard layouts. So in the end we simply cut one end of the connector off and soldered the wires to our project board directly. Table 1 shows the function of the different wires.

Connection to the PICAXE chip is made via a serial (RS232) link, so the wires can connect directly to the PICAXE input/outputs pins.

Although the VMUSIC2 supports CTS/RTS serial handshaking, we have not used that feature here, so it is essential to tie the green wire (CTS) to 0V. Note also that the VMUSIC2 'transmit' (output) pin connects to a PICAXE 'receive' (input) pin and vice versa.

The VMUSIC2 requires a nominal 5V supply on the red and black wires (we ran it quite happily at 4.5V from 3xAA cells; you could also use 4xAA NiCad or NiMH rechargeables to provide 4.8V).

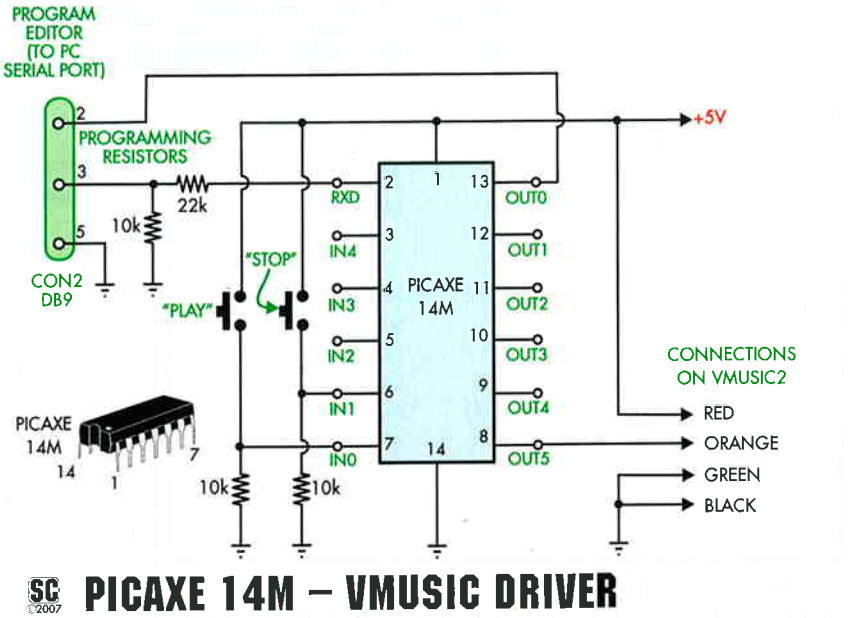
Connecting to a PICAXE-14M chip

The VMUSIC2 module supports serial connections at a 9600 baud rate. If you've been playing with PICAXEs, you'll know that the maximum baud rate of a PICAXE-14M is 4800 when running at the (default) 4MHz.

However if we double the internal clock speed of the 14M to 8MHz (via a 'setfreq m8' command) everything now runs twice as fast and so we get the desired 9600 baud rate!

Table 1 – Connections

VMUSIC2		PICAXE
1	Black	GND – 0V
2	Brown	RTS – not connected
3	Red	V+ – V+
4	Orange	RXD – output pin
5	Yellow	TXD – input pin
6	Green	CTS – 0V
7	(not used)	
8	Blue	RI – not connected



SC 2007 PICAXE 14M – VMUSIC DRIVER

Fig.1: the simplest possible connection to the VMUSIC2: just one signal wire plus power (green in this case must be tied to 0V). Below is the protoboard layout of this circuit.

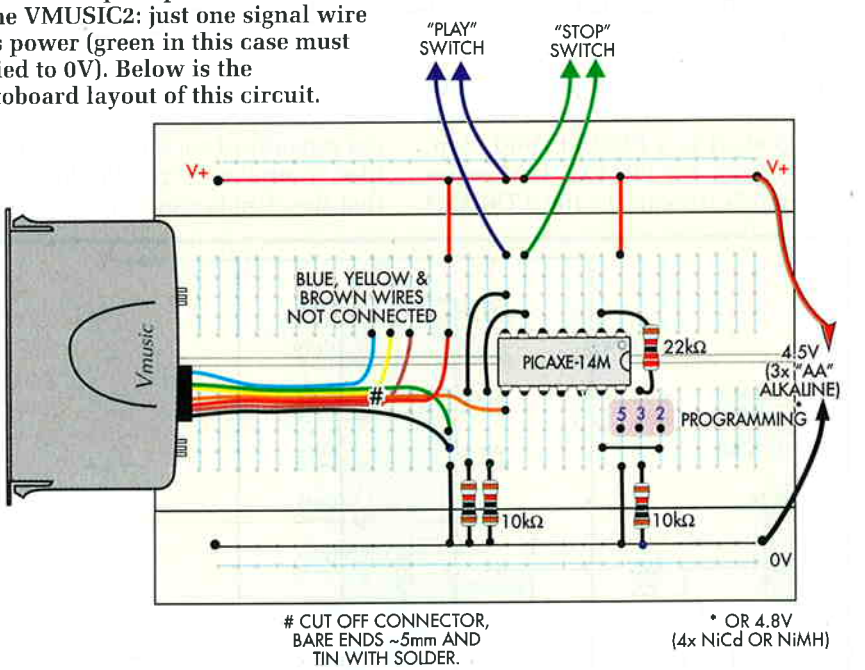


Table 2 - VMUSIC2 commands

Play track "filename.mp3"	serout 5,t9600_8, ("vpf filename.mp3",CR)
Play all tracks	serout 5,t9600_8, ("w3a",CR)
Stop track	serout 5,t9600_8, ("vst",CR)
Skip to Next Track	serout 5,t9600_8, ("vsf",CR)
Skip to Start of current Track	serout 5,t9600_8, ("vsb",CR)
Skip to Previous Track	serout 5,t9600_8, ("vsb",CR,"vsb",CR)
Pause	serout 5,t9600_8, ("e")
Resume (after pause)	serout 5,t9600_8, (CR)
Set Volume	serout 5,t9600_8, ("vwr",$0B,vol_right,vol_left,CR)
;where $00 = maximum volume, $FE is the minimum	
Suspend disk	serout 5,t9600_8, ("sud",CR)
Wakeup disk	serout 5,t9600_8,("wkd",CR)
Get firmware version	serout 5,t9600_8,("fwv",CR)

Program 1 – VMUSIC2 to PICAXE 14M (1)

```
#picaxe 14m                          ; set picaxe type

init:
      setfreq m8                     ; double speed
      pause 1000                     ; allow 500ms to wake-up

main:
      serout 5,t9600_8,("vpf 1.mp3",CR)   ; send play 1.mp3
      pause 20000                    ; wait 10 seconds
      serout 5,t9600_8,("vst",CR)    ; send stop
      pause 20000                    ; wait 10 seconds
      serout 5,t9600_8,("vpf 2.mp3",CR)   ; send play 2.mp3
      pause 20000                    ; wait 10 seconds
      serout 5,t9600_8,("vst",CR)    ; send stop
      pause 20000                    ; wait 10 seconds
      goto main
```

Program 2 – VMUSIC2 to PICAXE 14M (2)

```
#picaxe 14m                          ; set picaxe type

init:
      setfreq m8                     ; double speed
      pause 1000                     ; allow 500ms to wake-up

main:
      if pin0 = 1 then do_play       ; play switch pushed
      if pin1 = 1 then do_stop       ; stop switch pushed
      goto main

do_play:
      pause 10                       ; short debounce time
      if pin0 = 1 then do_play       ; wait until switch released
      serout 5,t9600_8,("vpf 1.mp3",CR)   ; send play 1.mp3
      goto main

do_stop:
      pause 10                       ; short debounce time
      if pin1 = 1 then do_stop       ; wait until switch released
      serout 5,t9600_8,("vst",CR)    ; send stop command
      goto main
```

The four PICAXE program listings above and right are all that you need to get the PICAXE to talk to the VMUSIC2 – or is it sing to it? Don't forget the 08M is being run at double speed so all your normal time-dependent variables must be doubled!

Fig.1 shows the simplest connection method possible, just one wire (and power) to a PICAXE-14M chip. In this mode the PICAXE-14M issues commands directly to the VDRIVE2 module without feedback.

Program 1 shows a program to play ten seconds of each of the two music files '1.mp3' and '2.mp3'. Remember that the chip is running twice as fast as normal, so to get a 10 second delay you actually have to enter 20000 (milliseconds) for the pause command!

You could use the Revolution Education PICAXE-14 project board (AXE117) for testing but it would be quite simple to make up your own pc board/stripboard layout or, as we have shown here, use the breadboard approach taken with many of the PICAXE projects in SILICON CHIP.

'vpf filename' and 'vst' are the commands required by the VMUSIC2 to play and stop mp3 files. Table 2 shows all the most common VMUSIC2 commands.

Note that as each letter in the MP3 filename uses up memory in the PICAXE, it is far better to rename your files "1.mp3", "2.mp3" etc. rather than "Meatloaf - Bat out of hell.mp3"!

Of course you could now add switches to the PICAXE circuit, so that when a switch is pressed the song is played. Program 2 shows this type of idea, with two switches connected to PICAXE inputs 0 and 1.

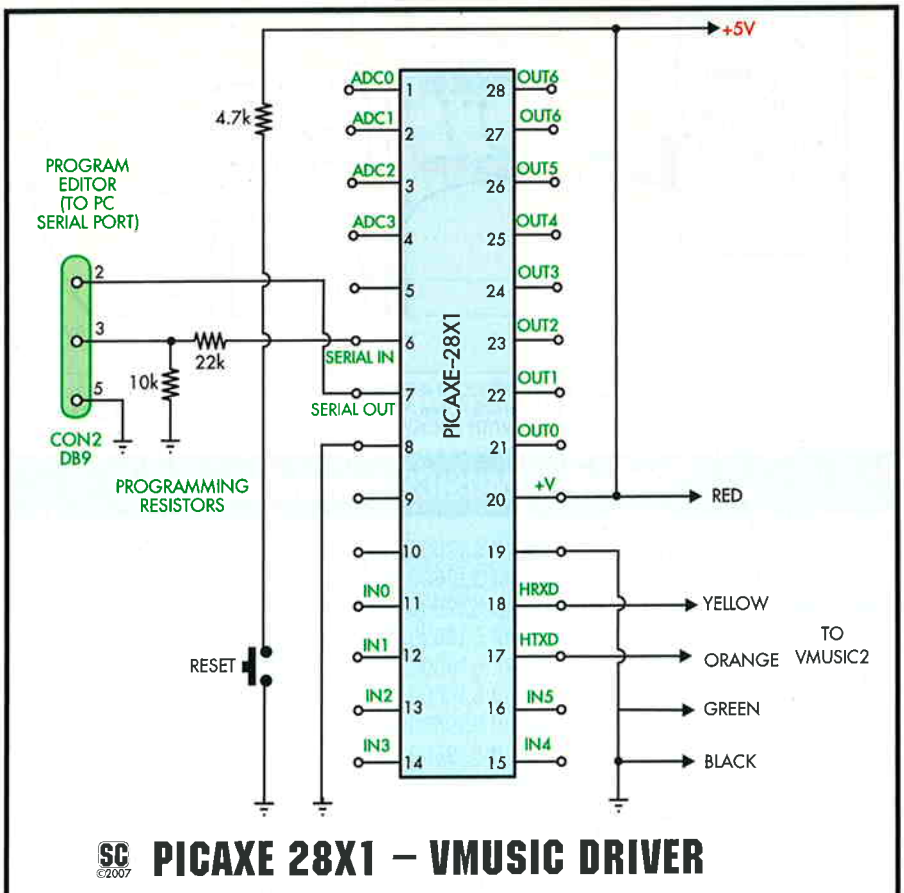


Fig.2: here the VMUSIC2 drives the new PICAXE-28XI chip. You not only get more control and functions but sixteen times the memory!

Connecting to a PICAXE-28X1 chip

Although the VMUSIC2 will work fine with a PICAXE-14M chip, you will probably soon run out of memory on more complex programs. In this case it would be advisable to switch to the new PICAXE-28X1 chip, as it has 16x more memory! The PICAXE-28 protoboard (AXE022P) is ideal for

Program 3 – VMUSIC2 to PICAXE 28X1

```
#picaxe 28x1      ; set picaxe type

symbol first_byte = b0
symbol point = b1
symbol temp = b2
symbol loopcounter = b3

setup:
      ; setup serial hardware
      ; at 9600 with background receive
      hsersetup b9600_4,%01

init:
      ; Send Es until the unit responds correctly
      hserout 0,("E",CR)
      gosub       get_response
      if first_byte <> "E" then init

main:
      ; check to see if a drive is actually inserted
      ; response will start D for yes and N for no
      hserout 0,(CR)
      gosub       get_response
      if first_byte <> "D" then main

      ; play track 1.mp3
      ; response will start D if ok, C if not
      hserout 0,("vpf 1.mp3",CR)
      gosub       get_response
      if first_byte <> "D" then main

      ' play ten seconds
      pause 10000

      ' pause for 5 seconds
      hserout 0,("e")             ; note no CR here
      pause 5000

      ' play another ten seconds
      hserout 0,(CR)
      gosub       get_response
      pause 10000

      'stop
      hserout 0,("vst",CR)
      gosub       get_response
      pause 5000

      goto main

      ; Sub procedure to receive background bytes
get_response:
      pause 1000                  ; wait a while
      point = 0                   ; reset local pointer

      get point,first_byte        ; Save the first reply byte
      do
        get point,temp            ; get returned byte
        sertxd (temp)             ; transmit it
        inc point                 ; increment pointer
      loop while temp <> CR       ; if not CR loop

      hserptr = 0                 ; reset the background receive pointer
      return
```

Program 4 – logging

```
logging:
      readadc 1, b20              ; readadc value into variable b20

      ; create a log file called 'log.txt'
      hserout 0,("opw log.txt",CR)
      gosub       get_response

      bintoascii b20,b5,b6,b7     ; convert loopcounter byte to 3 ascii digits
                                  ; and write 8 bytes loop_xyz
      hserout 0,("wrf ",$00,$00,$00,$09,CR,"value ",b5,b6,b7)
      gosub       get_response

      hserout 0,("clf log",CR)
      gosub       get_response

      pause 1000

      goto logging
```

testing but again it would be quite simple to make up your own PC board/stripboard layout.

One of the new features of the 28X1 is its 'internal' enhanced hardware serial module. This module is far more efficient than the serial connection via the standard input/output pins, and also supports much higher baud rates (the 9600 required here is no problem at all!). It also allows serial receives in the background (while the PICAXE processes other tasks).

Fig.2 shows a slightly more complex connection, where the VMUSIC2 is connected to both the hardware serial in and hardware serial out pins. This now allows the VMUSIC2 to send replies and information back to the 28X1 chip – ie, we now know if a command has been received and understood.

Program 3 shows how to get replies from the VMUSIC2 module. This is achieved via the 'get response' sub procedure, which receives the serial replies from the PICAXE serial port hardware.

Each reply can be of different length, so the sub-procedure only returns when the terminating carriage return (CR) byte is received.

Data Logging

A secondary feature of the VMUSIC2 (and the primary feature of its cheaper, non-MP3, little brother, the VDRIVE2) is to read and write to files onto the USB thumb drive. This makes it ideal for data logging experiments.

Program 4 shows part of a program to use the fileopen (opw), file write (wrf) and file close (clf) commands. Further details for these commands can be found in the VMUSIC2/VDRIVE2 datasheets.

Summary

The VMUSIC2 is a neat, economical, solution to playing MP3 and WAV songs and sounds. It is easily interfaced to a PICAXE chip making it ideal for linking into many musical projects.

The file reading / writing functions will also appeal to many data-logging type experiments.

For further details, schematics and technical datasheets for the VMUSIC2/VDRIVE2 module please visit **www.vinculum.com** SC

SERVICEMAN'S LOG

I just hate doing repair quotations

Giving quotes to repair equipment such as a TV sets is not that easy. As often as not, providing an accurate quote means spending a great deal of time tracking down the fault, by which time the job has really been done. And if the customer then rejects the quote, you don't get a cent for your time.

I just hate doing quotations because of all the implications involved. The requests come in many different forms, often starting with a phone call which goes as follows: "I live in Outer Woop Woop. Do you do free quotes?"

In other words, are you prepared to drive all the way out to my place, strip down the set and repair it before you can give me a cast-iron guaranteed quote and then put it all back to how it was and return home – all for free. Not even charities do that.

Then you have the guy who thinks he is being really helpful because he has jammed his 150cm rear-projection TV in the back of his smallish station wagon and brought it in, expecting a free quote based on a quick view through the rear window. Obviously, I'm expected to fit my Kryptonite eye adaptor, remotely scan all the circuits and, without diagrams or test instruments, locate the exact fault and suggest a cheap fix.

Other clients think that by just quoting the set's model number is enough for me to surely know the cost of the repair.

For all these misguided people I have to tell them that free guesses are free because they are worthless. In most instances, I have to repair the problem first to be sure, because often the original symptom hides other problems behind it.

The insurance companies are more reasonable in that they will pay for the quote but this is still going to be a close guesstimate, because the cost of doing the full repair often exceeds the quote.

HOW TO **NOT** HATE DOING QUOTATIONS...

Dead Panasonic TX-21FJ50A

For example, I had a Panasonic TX-21FJ50A employing a GP-3 chassis come in dead. Apparently, it had been hit by a lightning strike during a storm and was the subject of an insurance claim.

Removing the set's back revealed absolutely no sign of any visible damage – no fuses gone, no resistors blown or blackened and no exploded semiconductors. The only clue I had was that there were no voltage outputs from the switchmode power supply and the only measurable voltage was +330V to the chopper IC (IC801, STRW6754), which would not decay at switch-off.

OK, you say, quote for the IC and you'll be right. Well, no! I ordered the IC and the 8.2V zener (D820) that "hangs" off it and fitted them first before even starting the quote. This was just as well because although this restored all the power to the set and the picture was back, there was now no sound.

I checked all the menus and the inputs and then – using a wet finger

– established that the sound output ICs were in fact working OK. I could even get noise out of the loudspeakers all the way back to the digital sound microprocessor (IC2102), a large-scale 80-pin surface-mounted IC.

The original part number of MSP-3410GAB83 is now substituted by CIAB00002133 and is pretty expensive and labour intensive to replace. So what was I supposed to do now? Buy this IC and spend a couple of hours replacing it so that I could be sure there was nothing else wrong and that this was the only thing left to repair?

The fact is, if I had done that and the quote had been rejected, I would then be down the mine by a serious amount – especially as this set isn't that expensive to replace lock, stock and barrel. In the end, it was a gamble I wasn't prepared to take and the set was written off.

The fact is, it is sometimes very difficult to keep costs under control, especially when you have a lot of logistics. By logistics, I mean getting the technician, test equipment and parts, etc to the inside of the TV. If a set has to be collected and delivered and is large, heavy and requires more than one person plus a large van, you can see how these logistics can create equally large expenses.

In order to overcome some of these problems, I try to just transport the chassis or the particular faulty circuit board back to the workshop but even this sometimes doesn't work.

Sony rear-projection set

I was recently called out to a Sony KP-E61SN11 61-inch (155cm) rear projection TV using an RG-1 chassis. The set was dead at switch-on and the client reported that it then took a very long time to come on.

When I arrived, I discovered that the set was kept in his garage at a block of units near the sea. The problem with rear projection TVs is that the board sits along the bottom of the cabinet and in order to work on it, it has to be at waist level. In this case, this wasn't possible, so I removed the power supply and took it back to the workshop where it was repaired, checked and tested.

The set was now going a little better but was still cutting out, so next I brought in the horizontal deflection board. This too was repaired, after which the set stayed on a bit longer. I then discovered that the HV unit was arcing so I had to order a new one. This was duly fitted but I still wasn't out of the woods, as the vertical deflection IC, which is on the next board, was faulty, as were the convergence ICs. All this travelling made the repair very expensive.

Samsung convergence faults

Recently, I have repaired several Samsung rear-projection TVs, mostly for convergence faults. These faults are usually the convergence ICs, which are STK392-010 amplifiers. And when they go, they invariably take a number of fusible resistors with them.

Unfortunately, one can never be sure of the full extent of the damage with these types of faults and whether it is one or both of the ICs. However, previous jobs can give you a ballpark range for a cost estimate.

Once I had a Samsung SP-42W5HPX/XSA – supposedly using a J42 chassis – with only a blue convergence error. Like all projection TVs, access to the lower chassis is poor and you have to unplug a lot of the wiring harness until the deflection panel is accessible.

I replaced the blue ICZ04 with an STK392-040 and measured all the resistors and fuses around the ICs but found nothing untoward. I then reassembled everything and switched on.

The sound came through OK but I was mortified to find that I no longer had any picture whatsoever. There was

Items Covered This Month

- Panasonic TX-21FJ50A TV set (GP-3 chassis)
- Sony KP-E61SN11 rear projection TV set (RG-1 chassis)
- Samsung SP-42W5HPX/XSA rear projection TV set
- Sharp LC30HV2M LCD TV
- LG PDP 42V7 plasma TV
- LG MS-1942 microwave oven
- Panasonic PT-AX100 projector
- Panasonic TX-68FJ50A TV set (GP3 chassis)
- JVC GNP420E plasma TV
- Metz A2TF97 TV set (696 chassis)

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no OSD either and the only sign of life I had was an arc of coloured spots on the top righthand side. However, the CRT filaments were obviously alight and I could hear the rush of EHT static. What's more, the deflection yoke was fully plugged in, as were all the other plugs as far as I was concerned. This set should now have been a goer, so why was it giving me grief?

I subsequently spent a great deal of time checking my work and retracing my tracks, all the time trying to restrain my rising panic. I mean, what could I tell my client? Was I going to have to come up with something along the lines of "oops, sorry, I've jiggered your set and as my car is full (and too small), I cannot take it back to the workshop to fix it. And no, you won't be able to watch telly all long weekend as I haven't got a loan set on board."

I could see all this going down like a lead balloon, especially if I also told them I had no idea what was causing the problem.

In the end, I decided the best course of action was to calm down, remove the whole chassis and start again. I examined the PC board for dry joints and resoldered a number of possible suspects. I also resoldered the heatsink earth connections and then reassembled the chassis very carefully and methodically.

I had a lot of problems reconnecting the focus lead to the focus assembly on the front. This was because I couldn't work out how the front escutcheon came off. It was probably being held on by a screw I couldn't see at top centre and I didn't want to use force in case I broke something that I would really regret. The service manual gave no clues.

Anyway, by keeping my cool, I eventually completed the re-installation and gingerly switched the set on.

I don't know what it was that I had done the second time around which I hadn't done the first time (or whether my prayers had simply worked) but I was extremely pleased to find that the picture had been completely restored and everything was now OK.

Thank heavens they're not all like that.

Who's the dirty rat?

One of the companies I sub-contract for is involved in selling, installing and servicing upmarket AV systems to clubs, hotels and even homes.

One such club had an AV system that also included PA (public address) and surveillance. This system had been going for over six months without problems but then the music system stopped working in one of the rooms. A service call was made and it didn't take long to find a break in a cable behind the rack of amplifiers. This was quickly repaired, after which the system worked normally again.

A few weeks later, another service call was booked when a camera stopped working. This fault was tracked down to another cable being cut in a different location not far from the first. Once again, the repair was straightforward and the system was soon back on air.

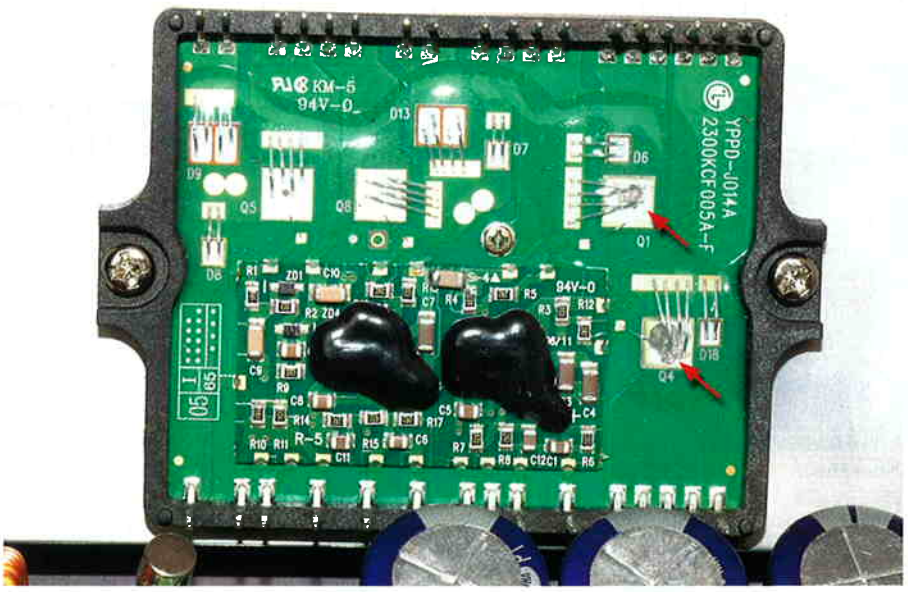
Unfortunately, that was not the end of the story. Over the next six months, numerous more calls were made to repair broken cables in different rooms and systems. Though none looked like they had been cut with side cutters, it was beginning to look like faulty cables, or, more disturbing, someone maliciously cutting them.

The mystery continued until a chance comment by one of the girls working in the club that she wouldn't be seen dead in the equipment room, as she had seen the size of the rat that lived in there! Finding and disposing of the rodent halted any further service calls!

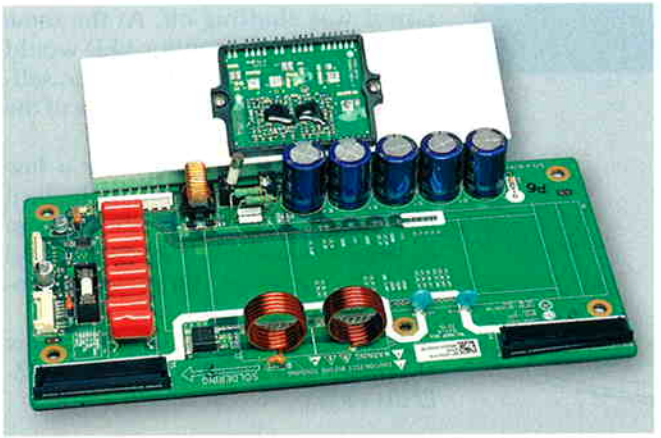
In fact, this story reminded me of another many years ago about a black and white TV with no sound in a take-away restaurant. When the back was removed, the fault was easy to spot – the loudspeaker cone had been totally eaten away by rodents!

LG plasma TVs

In previous Serviceman's Log articles I have mentioned replacing the Z Sustain, Y Sustain and Control Boards in LG manufactured plasma TVs to-



A close-up view of the IC underneath the heatsink on the Z SUS board in LG plasma sets. Note the discoloration beneath transistors Q1 & Q4 (arrowed)



It takes a lot of effort to desolder the IC – just one of the reasons why the Z SUS board is not a repairable item.

gether as a kit (Part No: 6871VSNB03E). The reason for this is that they are all matched, modified and upgraded. Most times, the no picture problem is due to fuse FS1 (+VS) T4.0AH going open circuit because of the IC underneath the heatsink on the Z SUS board.

The accompanying photograph of the IC clearly shows the discoloration of Q1 and Q4 underneath the clear epoxy resin. The board is not considered repairable to component level. It takes a lot of effort just to desolder the IC and no, it is not available as a spare part.

Sharp LCD TV

We had a Sharp LC30HV2M LCD TV come in under warranty with the complaint that it "made a popping noise and smelled". Well, you would complain about that!

When we got it on the bench, the set was actually dead. Obviously, the reported symptoms were its last dying throes. I soon found that FET Q1 (2SK2917) was short circuit and a quick look around showed a fair bit of destruction. Most manufacturers insist you just change the board, so we ordered a new "Display Power Unit".

We were therefore quite surprised when we received a box of 22 parts instead – mostly surface mounted components (parts kit BQC-30HV2/4-1 – see Service Bulletin CTV199R). Not only that, they also suggested we resolder both ends of nine other surface-mounted resistors.

We were somewhat annoyed with this as there was a fair bit of work involved and we don't get much for warranty repairs. Anyway, we attended to these dry joints first and were surprised at how bad they were for surface-mounted components. When you heated one end, the part actually began to move!

When we replaced the parts, we found only about half of them to be faulty but – get this – it still didn't fix the power supply! Further detailed investigation revealed that R31, the 10kΩ bias resistor to Q9 (2SK2717), was high at 18kΩ. Replacing it finally fixed the problem.

LG microwave oven

We recently experienced an unusual problem with an LG microwave oven with no display. When we removed the control module, we checked the small mains transformer to find it open circuit. Easy, we thought – just order a new one and replace it, which is what we did to find it made no difference!

Like to Phidget ? Phidgets

Phidgets are an easy to use set of building blocks for low cost sensing and control from your PC. Using the Universal Serial Bus (USB) as the basis for all Phidgets, the complexity is managed behind an easy to use and robust Application Programming Interface (API). Applications can be developed quickly in Visual Basic, VBA (Microsoft Access and Excel), Labview, Java, Delphi , C and C++.

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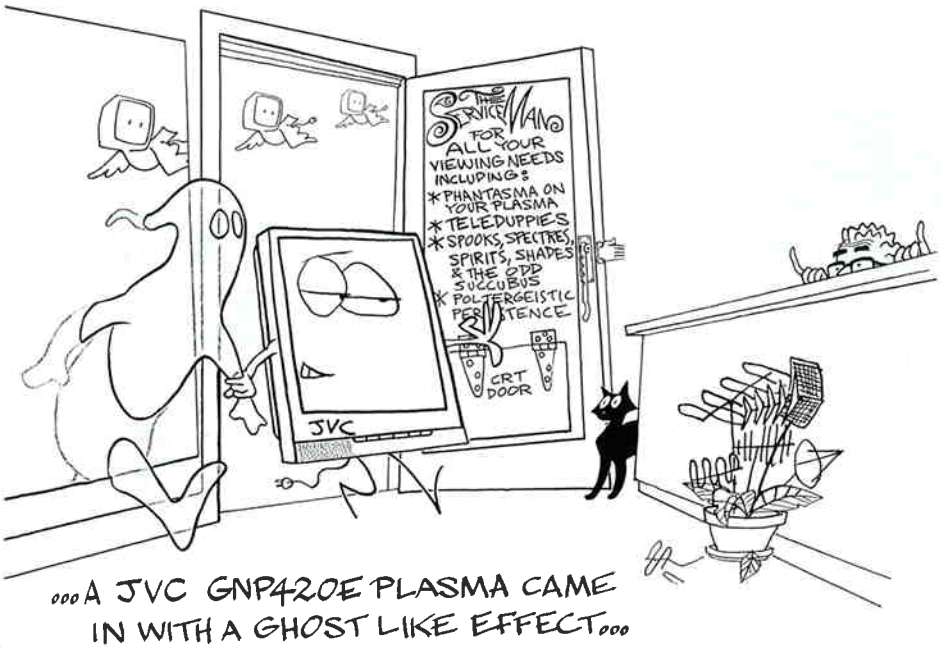

...A JVC GNP420E PLASMA CAME IN WITH A GHOST LIKE EFFECT...

Next, we checked both the new and old transformers to find both now had continuity which meant we had obviously misdiagnosed. In fact, it wasn't until we checked a few other parts like resistors and found that they too measured open circuit that we worked out what was happening.

These boards are now sprayed with totally invisible shellac which acts as a very good insulator. This means that in order to check components, you either need to resolder the connections or use a meter with extremely sharp probes to penetrate through to the PC board tracks.

So it fooled us. In this case, it was the display itself that was faulty.

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The ghostly JVC plasma

We recently had a JVC GMP420E plasma set come in with a ghost-like effect. It is hard to describe but this symptom is somewhat like CRT persistence, where a bright object remains in the background of the picture after the scene has changed. In addition, the picture was snowy, even on AV mode.

Technical support advised us that this was due to a fault in the scan and control modules, so this set was beyond economic repair.

Panasonic projector

We had a Panasonic PT-AX100 projector come in under warranty, the owner complaining that it was unexpectedly shutting down a minute or so after it started.

We found that after the lamp had been on for about 80 seconds, the power was shutting off. At the same time, the power monitor LED would go orange and start to flash. The self-check screen indicated a failure of the iris unit ("OK" LED turns red).

What happens is that after a few hundred hours of operation, the heat inside the unit causes the mechanism to begin to intermittently seize. And once the iris stops, the projector protection circuit cuts in.

A new modified iris unit is now supplied by Panasonic – Part No: TXZ-EN01VKD3.

Panasonic TV set

I recently made a house call on a Panasonic TX-68FJ50A (GP3 chassis), the owner complaining that there was no picture. Well, that was quite true – there was a black raster, the OSD (on-screen display) menu functions were all working and the sound was OK too. If tuned to a blank channel, the screen would mute to blue.

Turning up the G2 screen control revealed the faint imprint of a picture. I then checked the voltage on the beam limiter pin on the flyback transformer and this revealed a negative voltage instead of a positive one.

Following the path past R558, I soon came across R557 which is connected to the +140V rail. This resistor was open circuit but I was faced with a problem as to what its real value should be. The circuit showed it to be 88.8kΩ but the 5-band resistor on the board was green, white, black, red and brown, which reads 59kΩ.

Initially, I fitted an 82kΩ resistor which restored the picture. I then decided to replace it with 27kΩ and 33kΩ resistors in series (= 60kΩ). That made no discernable difference to the picture quality, so why do the designers fit a 1% non-preferred value when it isn't critical?

Metz TV set

A Metz A2TF97 TV (696 chassis) was stuck on PR1 (DVD AV) and no control functions were working, either via the front panel or the remote control, It was as if a button was stuck permanently on.

The cause was an I^2C bus line that was shorting to ground. Pinpointing the exact location of the fault meant disconnecting each device on this bus until the short was cleared. This turned out to be the first tuner and a new one restored all the functions. SC

57→

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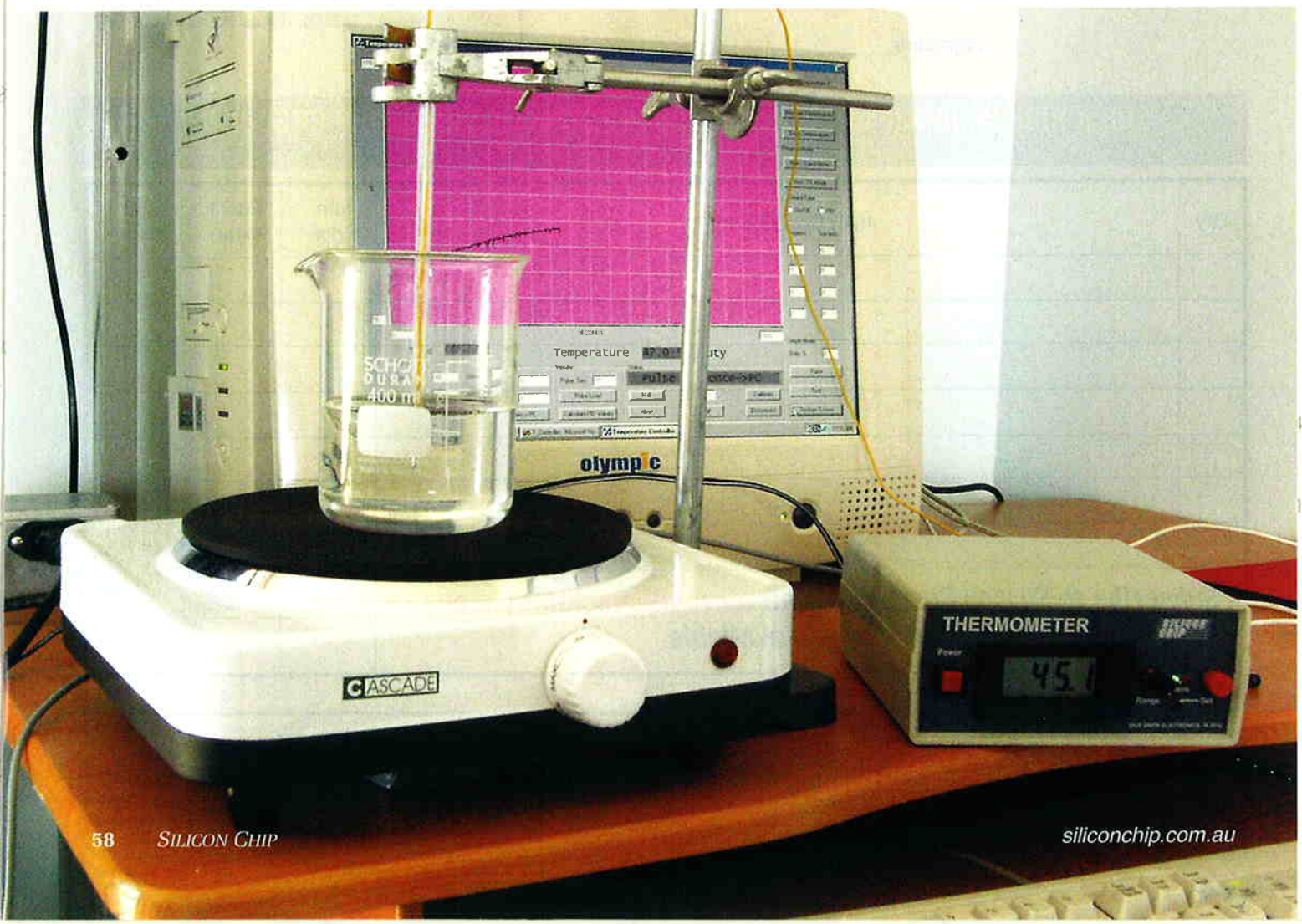
For temperature control without overshoot

PID TEMPERATU

What's a PID controller? PID stands for "proportional integral differential" and relates to a process which seeks to continuously correct the error between a measured variable and a desired setting by calculating an appropriate correction process. In practice, it can largely avoid the large overshoots and undershoots that occur in simple temerature control systems.

By LEONID LERNER



RE CONTROLLER

Keeping tight temperature control is essential in many processes. For instance, good temperature control of a PC board etching bath is essential for best results.

Too low a temperature and the process will be very slow, while too high a temperature will cause the etch resistant film to degrade and the solution to steam appreciably.

Another, arguably more important, process where precise temperature control is vital is in a good home brew!

Getting good temperature control is not as easy as it may seem. Consider the setup in in the photo at left and represented below in Fig.1.

When the hot plate is turned on, heat passes from the hotplate to the solution through the walls of the container.

When the temperature of the solution reaches the desired value, the controller (the Digital Thermometer/Thermostat featured in the August 2002 issue of SILICON CHIP) switches the hot plate off but the temperature will continue to rise.

This is because there is significant thermal resistance in the surface contact between the container and the hot plate, so that the temperature of the hot plate when it is turned off is much higher than the set temperature.

The actual amount by which it is higher than the set temperature depends on the relationship of the set temperature to the maximum temperature attainable by the hot plate.

For instance, a 2000W hot plate was found to have heated to 150°C when the temperature of the solution reached the optimal temperature of a persulphate bath, 65°C.

Heat therefore continues to pass through the walls of the container and the temperature continues to rise, until the hot plate and the solution are in thermal equilibrium.

The result is temperature overshoot. Furthermore, after the peak temperature has been reached the system starts to cool down towards the desired temperature and the hot plate turns on again at the set temperature.

The overshoot repeats, although this time it is smaller. The end result is that with on/off control, the temperature of the system in Fig.1 oscillates periodically.

For etching PC boards, the result is the inconvenience of a lot of steam being generated but for many processes such as distillation, overshoot is simply not permissible.

Our aim here is to understand the operation of the thermal delay of the system in Fig.1 and counteract it to achieve good temperature control. To do this we need to design a controller which has a more complicated response than simply on/off.

But first we shall develop a model to make it easier to understand what is happening.

It turns out that the thermal setup on the left side of Fig.1 is well modeled by an electrical circuit consisting of resistors and capacitors, as shown on the right side of Fig.1. This is more than just a convenient picture; it is based on

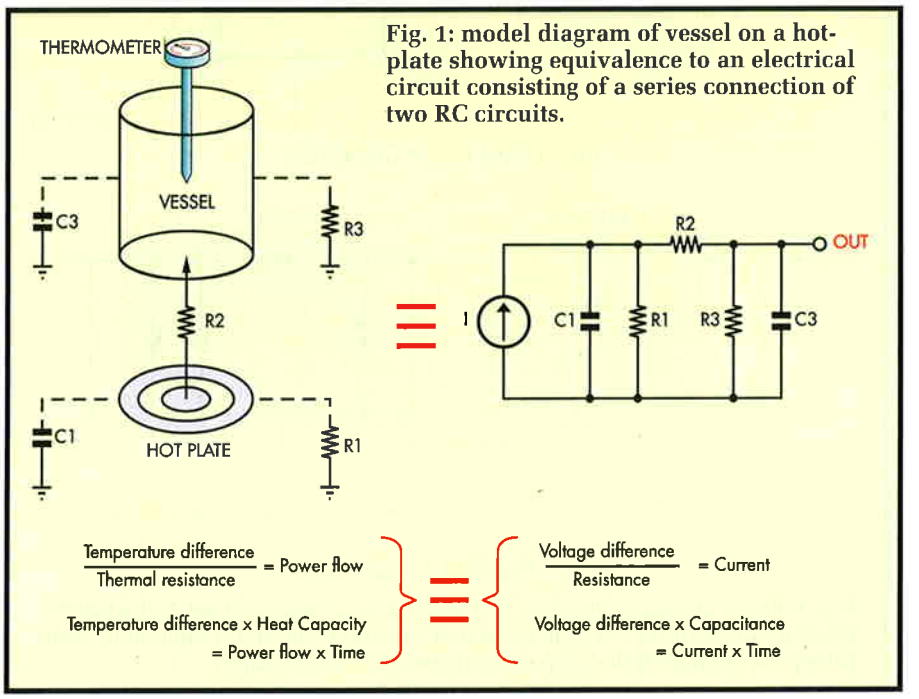


Fig. 1: model diagram of vessel on a hotplate showing equivalence to an electrical circuit consisting of a series connection of two RC circuits.

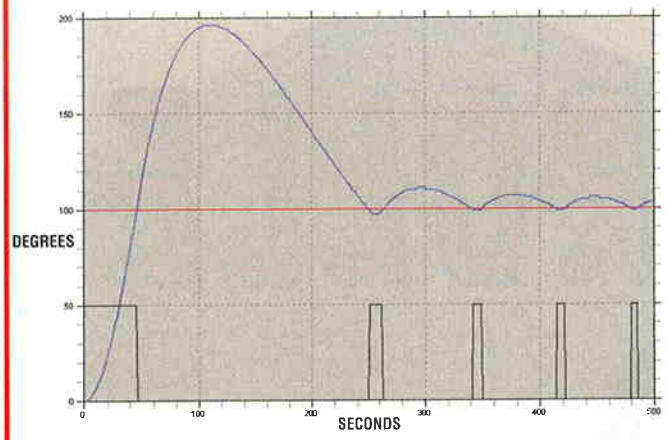


Fig.2: temperature plot of a typical "switched" hotplate which has an initial large overshoot, followed by a series of smaller over-temperature peaks.

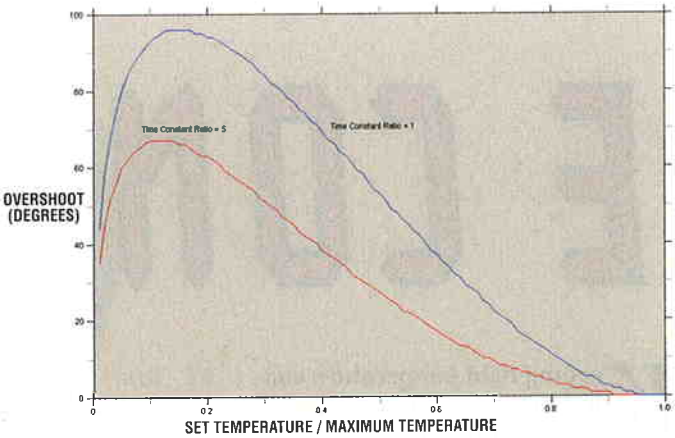


Fig. 3: temperature overshoot for a typical vessel on a hot-plate as a function of set temperature for equal time constants (blue line) and their ratio equal to 5 (red line).

actual mathematical correspondence. If we make the equivalence

temperature	<----->	voltage
power	<----->	current

then the equations in Fig.1 show that Newton's law of cooling corresponds exactly to Ohm's law, while the Law of Heat Capacities corresponds exactly to Coulomb's law for the capacitor.

Therefore we can view the thermal system as a good approximation to a passive resistor-capacitor network.

The heat capacities of the hot plate and of the vessel correspond to capacitors C1 and C2, the thermal resistance between the hot plate and the vessel corresponds to resistor R2, while the heat loss of both hot plate and vessel to the surroundings is modelled by resistors R1 and R3, respectively.

The ambient temperature in the thermal system then corresponds to earth potential in the electrical circuit. However, it is easy for confusion to arise due to the fact that in the correspondence thermal power is equivalent to electric current and not to electric power.

Thus expressions such as V^2/R and $1/2\ CV^2$ which correspond to power and energy in electric networks have no simple interpretation in the equivalent thermal circuit.

Theory of PID Control

If we use a computer to switch the electric circuit of the right side of Fig.1 on or off, depending on whether a preset temperature has been reached, the response is shown in the graph of Fig.2.

It is characterised by an initial large overshoot, followed by a series of smaller oscillatory overshoots, which tend to an oscillation of constant amplitude above and below the preset temperature.

In fact, the initial overshoot and oscillation amplitude are easily calculated in terms of the time constants of the RC circuit and the set voltage, as shown in Fig.3.

The overshoot depends on two ratios; the ratio ($\tau1:\tau2$) of the time constants of the hot plate and vessel RC circuits, and the ratio of the set temperature to the maximum steady state temperature, when the hot plate is on continuously.

From Fig.3 we can establish a simple rule of thumb to determine whether overshoot is likely to be a problem in a given situation.

First of all, if the maximum temperature achievable by the heating (or cooling) element, when it is on continuously, is much greater in

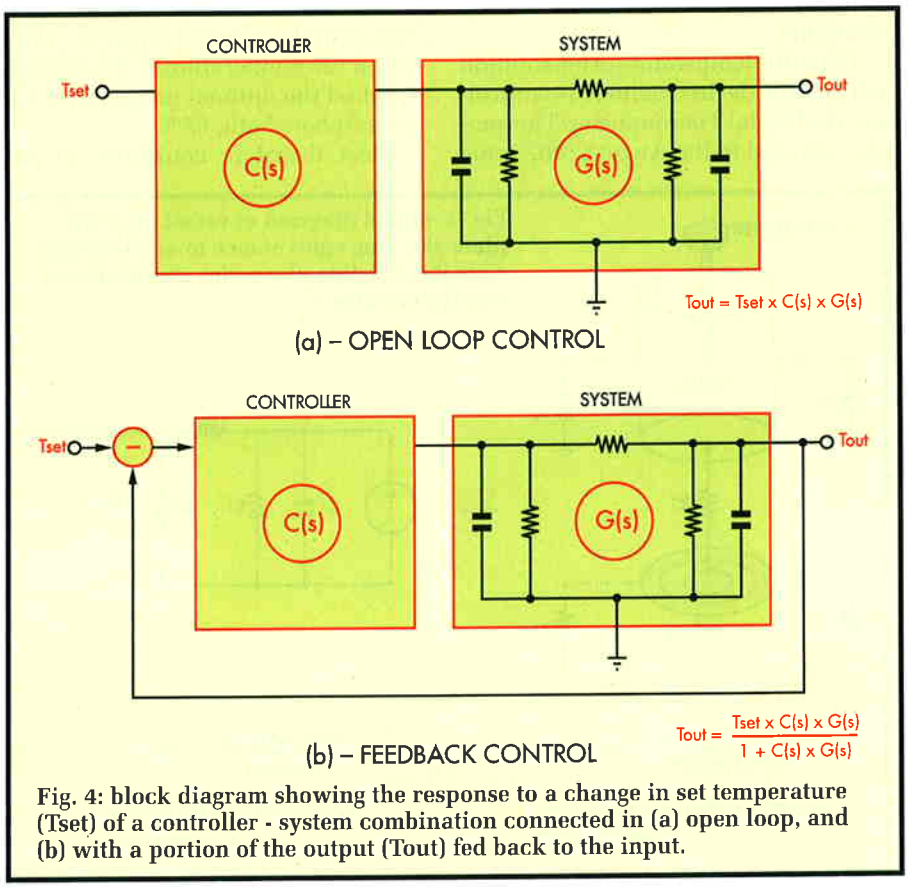


Fig. 4: block diagram showing the response to a change in set temperature (Tset) of a controller - system combination connected in (a) open loop, and (b) with a portion of the output (Tout) fed back to the input.

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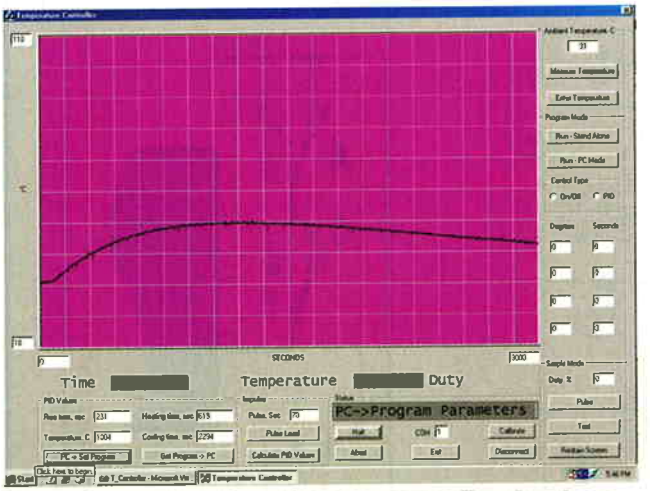

Fig. 5: the user interface of the PID controller showing a typical impulse response.

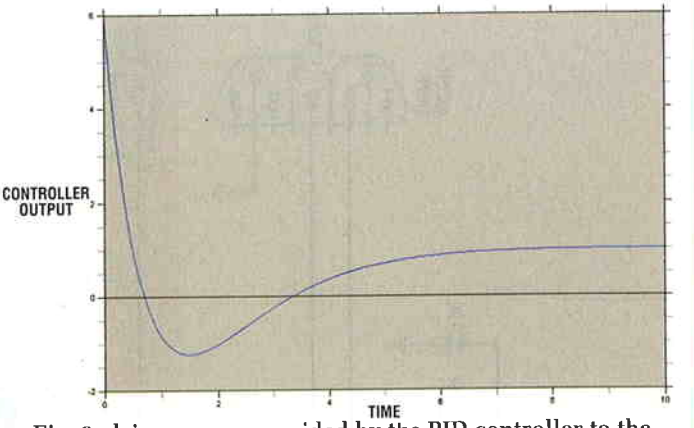

Fig. 6: drive energy provided by the PID controller to the thermal system as a function of time for a critical response. Starting with 100%, the drive has a trough to avoid overshoot, and then equilibrates to a steady-state value.

magnitude than the desired temperature, then substantial overshoot is a possibility.

For it definitely to occur, the time constants of the heating element and the heated vessel must also be within an order of magnitude of each other.

So if $\tau 1$ is much greater than $\tau 2$ for example, the vessel reacts much faster than the hot plate and is able to follow its temperature much more closely, meaning there is no substantial overshoot.

Similarly, if the set voltage is near the maximum voltage, no large overshoot is possible since we are operating close to the maximum temperature anyway. Both these criteria are satisfied for the usual situation of a vessel heated on a hot plate. The equivalent maximum temperature for typical hot plates is of the order of 1000°C (which is the value used in Fig.3) and so is much greater than typical set temperatures.

To cope with the overshoot problem we adopt a simple strategy. The response of the equivalent RC circuit to a step in the set voltage, shown in Fig.2, is a calculable function of the circuit.

If we feed this circuit from a controller with an exactly inverse response, then the response of the whole system will be flat – ie, it will behave like a resistor. The situation is shown in Fig.4a.

The response of the RC network in Fig.1 we write as G(s), while the response of the controller we write as C(s). Then if we choose a controller so G(s)C(s) = R, the combined circuit behaves as a resistor, so that the output voltage is related to input control current by Ohm's law:

Vout = Icontrol x R.

For a resistor, on/off control gives no overshoot.

The controller with the required response, R/G(s), does not have to be built physically. We can calculate this response on a microprocessor and pass the digital values it generates to a DAC which provides the control currents. The system is still driven by the computer directly, not in simple on/off fashion but with a R/G(s) response.

However we have to investigate our ability to realise the R/G(s) controller response using a microcomputer-DAC combination.

It turns out this is a problem because G(s) for a two time-constant system requires infinite control currents to achieve an inverse response. For finite voltages we cannot achieve G(s)C(s) equivalent to a resistor.

The best we can do is approximate a two-pole RC network with a single time constant τd, which we can choose so that Tset is reached in the minimum possible time with no oscillation. This corresponds to what is called the "critical response".

Obviously, if we set $\tau d = 0$ we get the inverse response, which as we stated above is impossible. Hence we have to determine the minimum value of τd corresponding to our maximum current.

Our controller drive will initially be 100% so as to attain the preset temperature as quickly as possible and will then drop quickly to avoid overshoot, before leveling off to its steady state value. Fig.6 shows the result. If we push the time constant of the response below a critical value, a point will be reached where negative drive is required. Since this is impossible, overshoot will result.

Hence the critical value of τd corresponds to that where the curve of Fig.6 just touches the horizontal axis.

What we are required to do to complete this program is to measure the system response G(s). This is most simply done by pulsing the circuit for a set period, usually of the order of a minute and measuring the response.

For typical systems the temperature hardly rises during the pulsing (this is why it is called an impulse response) and what we see is a large overshoot after the power had been turned off, followed by decay to ambient temperature. Typical results obtained with the present project are shown in the diagram of Fig.5.

In fact, this curve is characterised by just three parameters. The first is the maximum steady-state temperature. We cannot measure it directly because this would mean overheating the hot plate, in which case other thermal processes, such as convection and radiation will come into play.

Our thermal to electrical correspondence is based only on conduction, so the actual maximum temperature of the hot plate is substantially less than we estimate from the curve in Fig.5.

However this does not matter, provided we operate the system at temperatures below about 500°C or so, when these other processes are unimportant.

The other two parameters are the

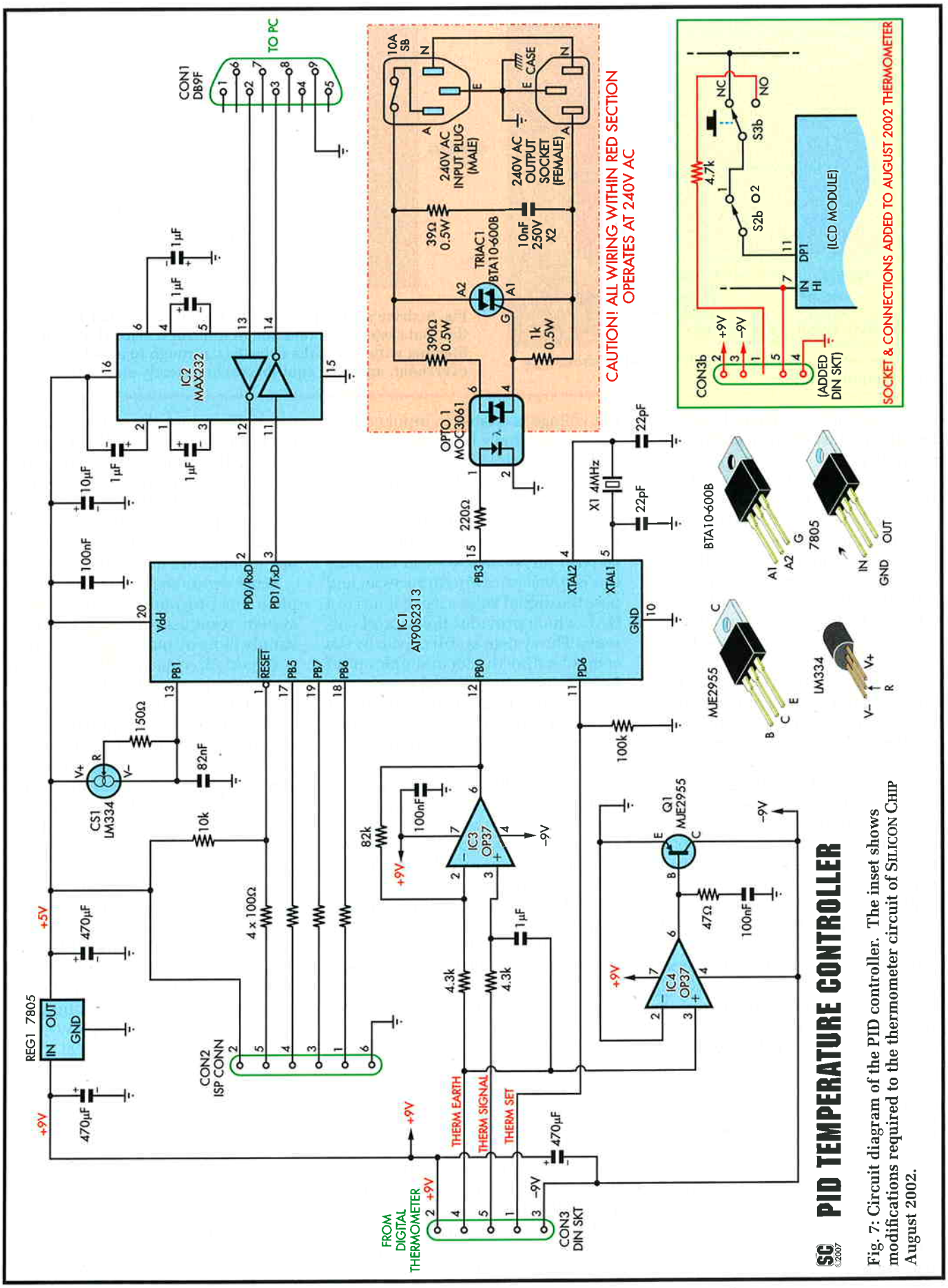

Fig. 7: Circuit diagram of the PID controller. The inset shows modifications required to the thermometer circuit of SILICON CHIP August 2002.

time constants τ1 and τ2, which in the usual case when R2 is small, can be understood as the heating constant of the hot plate, which is usually smaller than the third parameter, the cooling constant of the hot plate-vessel combination.

All three parameters are extracted by the software from the curve in Fig.5.

Another problem with the open loop controller configuration (Fig.4a) we have been considering, is that it relies on our ability to measure model parameters exactly, allowing for no variations in time.

PID control

The fact that we are not able to measure system parameters exactly, as well as slight variations in these parameters during the experiment (for instance a breeze arising) means we have to introduce negative feedback into the system to reduce errors. This changes the system from open-loop to closed-loop as shown in Fig.4b. The output temperature is sampled and fed back into the controller input.

In effect, the system functions as a feedback amplifier. And just as in that case, the feedback changes the response of the system.

In order to achieve an RC type of response now, it turns out that the controller can be of the proportional-integral-differential variety (PID).

This is a particularly simple type of control where the control current is based on the sum of three terms: a term proportional to the input voltage to the controller, a term proportional to the integral of this voltage, and a term proportional to the differential of this voltage.

The constants of proportionality are the tricky parts requiring calculation and are determined by the requirement that we obtain our desired RC response with minimum τd. These values, as we have seen, are available directly from the impulse response.

Thus for a new system we operate the controller by carrying out an impulse response (this can take up to a few hours depending on the system) and registering its parameters as well as the ambient temperature. These can also be entered manually, if desired.

For instance, the value of τd can be decreased from critical, if a faster response is desired and some overshoot can be tolerated. Now we enter the set temperatures and durations we wish to cycle our system through (the thermal regimes of the system) and run the controller.

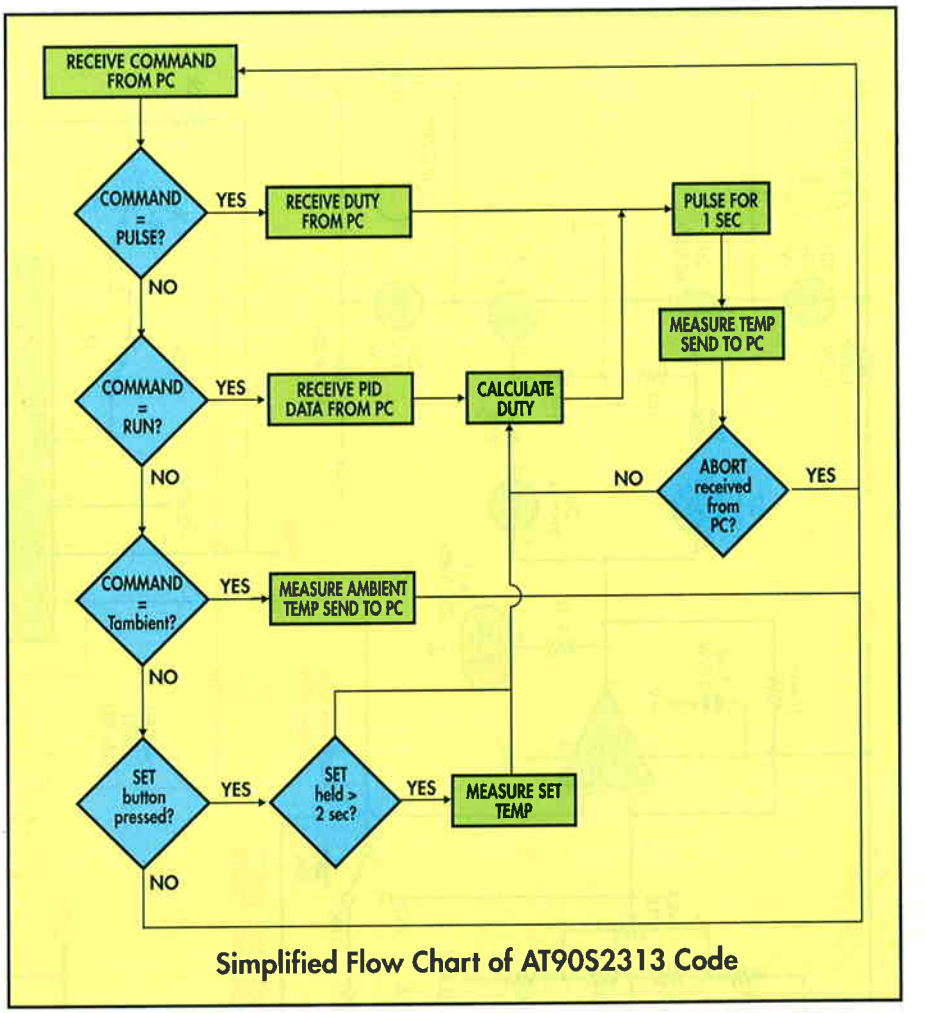

Fig. 8: this flow chart shows how the microcontroller interprets a range of commands from the PC. During a thermal program the controller executes the loop calculate duty - pulse - measure on the RHS of the flow chart.

Circuit operation

The hardware part of the project is fairly straightforward as can be seen from the circuit diagram of Fig.7. It is designed to be used in conjunction with the Digital Thermometer/Thermostat project referred to earlier and published in the August 2002 issue.

The PID Controller circuit is powered from the ±9V regulators on the Thermometer PC board and is interfaced to the LCD module in the same circuit.

The heart of the PID Controller circuit is the AT90S2313 microcontroller IC1, which in addition to an extensive ALU (arithmetic logic unit), features 1kb of program flash memory, 128 bytes each of SRAM and EEPROM memory, a UART and a fast analog comparator.

The analog comparator is used in conjunction with the LM334 constant current source (CS1) and the 82nF capacitor to form a simple tracking ADC (analog to digital converter) which the microcontroller uses to measure temperature.

The voltage signal representing temperature is passed to the ADC by op amp IC3, configured as a non-inverting amplifier with a gain of 20. Its high-impedance non-inverting input is fed directly from the digital thermometer via a shielded 4-core cable and DIN socket CON3.

Thus IC3 provides minimum loading to the thermometer circuitry. This is important since the digital thermometer outputs voltages in the range 0-200mV and its temperature precision corresponds to a voltage of 100uV. Since the ADC has an input voltage range of 0-4V, maximum precision and minimum non-linearity due

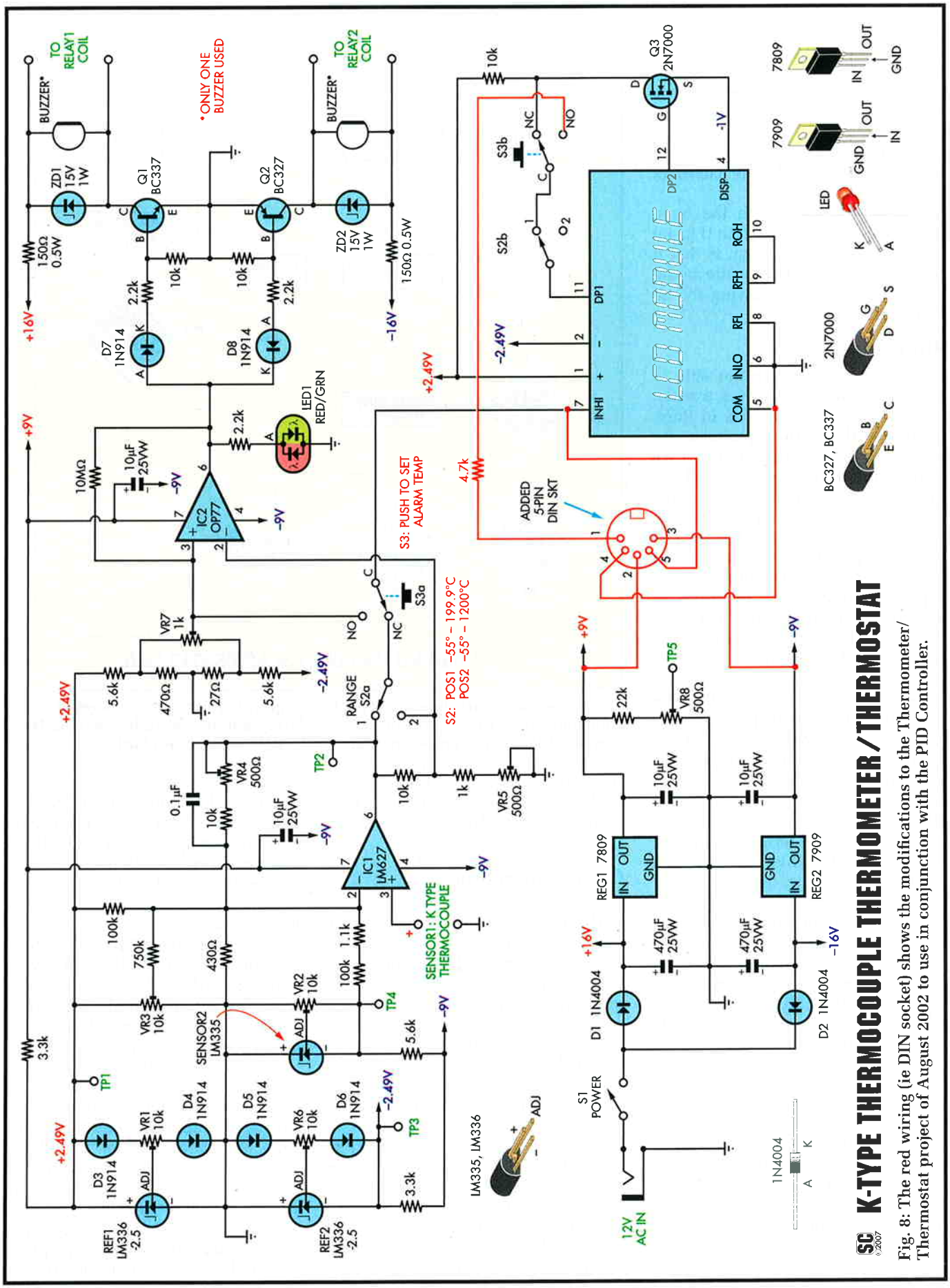

Fig. 8: The red wiring (ie DIN socket) shows the modifications to the Thermometer/Thermostat project of August 2002 to use in conjunction with the PID Controller.

to input offset requires a gain of 20 for IC3. The OP37 op amp was chosen here for its low-noise/input offset characteristics.

The AT90S2313 (IC1) drives the load (ie, a 240VAC heating element) from its PB3 output (pin 15) via an optically coupled driver MOC3061 (OPTO1) and an insulated tab Triac (TRIAC1).

OPTO1 provides zero voltage switching of the Triac for minimum electromagnetic interference. Resistor R1 is used to limit the current to the MOC3061 LED consistent with reliable triggering.

Communication with an optional PC is provided via the UART serial interface of the AT90S2313 using outputs PB0 & PB1 and the MAX232 level converter, IC2. The latter changes the unipolar 0-5V signals of the AT90S2313 to the ±10V of the RS232 specification. The serial interface is used by the PC to send control codes to the microcontroller and receive digitised values of the temperature.

As mentioned above, the PID circuit is powered by the ±9V supply rails of the Digital Thermometer via the 4-core shielded cable and 5-pin DIN socket CON3.

Negative current arrangement

A problem would have arisen if we had attempted to power the microcontroller and MAX232 directly from the digital thermometer, since these require a single +5V supply. Then the supply for the digital circuitry would share a common ground return path with the analog temperature signal and since the latter must be precise to 100µV, spikes due to load switching and UART transmission would be superimposed onto the signal due to the voltage drop across the connecting cable.

To circumvent this problem, the negative currents from the AT90S2313 and MAX232 are returned to the -9V supply, instead of the digital thermometer ground, via the PNP power transistor Q2. Its emitter is held at ground potential (0V) by the voltage follower, op amp IC4.

Thus, the earth line from the digital thermometer only carries signal current.

The controller can be run in standalone mode without serial connection to a PC and to support this, triggering of the controller by the temperature set button of the Digital Thermometer is provided.

The sensing is performed at PD6 (pin 11) of the AT90S2313, which detects a train of pulses generated by the digital thermometer when the set button is pressed. These pulses are normally generated by the decimal point driver of the thermometer's LCD panel.

The original digital thermometer was wired in such a way that the decimal point is disabled when the set button is pressed and this is used by the PID Controller circuit.

Note that in the original thermometer project the "temperature set" button was wired as a two-contact switch, which will therefore still function if the two wires are interchanged. In the PID project all three contacts of the switch are used, hence one must ensure the wiring is as per the circuit of Fig.7.

Fig.8 shows the complete circuit of the Digital Thermometer with the necessary modifications to connect it to the PID controller. These changes are shown in red.

PID software

Most of the project complexity is in the software but unless you want to examine the source code, you only need to acquaint yourself with the user-interface screen shown in Fig.5.

Although the controller can be used to control the load in stand-alone mode, a PC is required initially to set the load parameters.

Once the PC is connected via the serial cable to the programmed microcontroller and the latter connected to the powered digital thermometer, the PC application can be launched, whereupon the screen of Fig.5 appears.

The first step is to make the software connection to the controller box. This is done by selecting the appropriate COM port (1-4) and pressing any command button.

For first time use, the test button is best. If no error message appears, a connection has been made.

The controller has several modes of operation, as shown by the simplified (not all-encompassing) flow chart in Fig.8. The test and pulse modes can be started immediately. The test mode pulses any load connected to the controller at 50% duty cycle and sends temperature values to the PC, which graphs them. The pulse mode is similar except a duty cycle percentage must be entered in the appropriate edit box.

The other modes require a thermal regime to be entered. This is done by entering up to four different temperatures and durations in the appropriate edit boxes.

Following this, the ambient temperature needs to be recorded. One must either enter a known temperature and press the enter button on the screen, or press the measure button and let the controller measure it as the current temperature of the probe.

The mode of temperature control is then chosen. If overshoot is not expected to be a problem (for instance

Parts List – PID Temperature Controller

1 diecast metal case, 115 x 55 x 90mm (eg Jaycar HB 5042)
1B9F 9-pin DIN socket (CON1)
1 6-pin ISP connector, PC mounting (CON2)
1 5-pin DIN socket (CON3)
1 240V male IEC plug, fused
1 240V femaie IEC socket
17 10mm M3 screws
8 10mm nuts & washers
4 10mm M3 threaded standoffs
1 10mm M3 csk screw, nut and washer.

Semiconductors
1 AT90S2313 IC (IC1)
1 MZX232 RS232 interface (IC2)
2 OP37 low noise op amp (IC3,4)
1 MOC3061 Optocoupler (OPTO1)
1 BTA10-600B insulated tab Triac (TRIAC1)
1 7805 5V regulator (REG1)
1 LM334 current source IC (CS1)
1 MJE2955 PNP transistor (Q1)
1 4MHz crystal (XTAL1)

Capacitors
3 470µF electrolytic
1 10µF electrolytic
4 1µF electrolytic
3 100nF MKT polyester
1 82nF MKT polyester
2 22pF ceramic
1 10nF 250V AC Class X2

Resistors (0.25W, 1%)

1 100kΩ	1 82kΩ	1 10kΩ
2 4.3kΩ	1 150Ω	1 220Ω
4 100Ω	1 47Ω	

Resistors (0.5W, 1%)

1 1kΩ	1 390Ω	1 39Ω

the system is effectively a single-pole system), on/off control can be chosen since it is faster than PID.

Otherwise PID control is chosen and PID parameters need to be entered. These parameters (as well as the necessity for PID control) can be established by running the system in impulse response mode, that is, entering the pulse duration (the default is 60 seconds) in the corresponding box and pressing the impulse response button. The load will be turned on for the chosen duration and subsequently left alone, while the temperature is being recorded.

A system with manifest 2-pole (ie, two time-constants) response will show almost no increase in temperature during the on period and subsequently a large overshoot will be recorded, following by a cooling down period.

Data acquisition can be ended once a response resembling that in Fig.5 has been obtained. The essential element here is to allow the load to cool at least 20% below its peak temperature before ending data acquisition.

If at any stage during the run, the temperature or time limits of the waveform displayed on the screen are exceeded, or if different scales are desired for any of the two axes, new initial and/or final time/temperature values can be entered into the appropriate four edit boxes adjacent to the graph axes and the redraw button pressed.

At this stage the four PID parameters can be calculated immediately, by pressing the Calculate button. The values appearing in the corresponding boxes are the three main characteristics of Fig.1 discussed in the PID Control Theory section: the maximum effective temperature of the element and the time constants $\tau 1$ and $\tau 2$.

If the response shows no peak or a weak peak, error messages will appear. In this case one must either re-acquire the response (after changing the pulse duration appropriately) or run the load in on/off mode.

You can alter the PID parameter values if you wish, at this stage. This might be necessary to improve control, since the real setup can deviate from the model of Fig.1.

Thus if previous runs with the same system have shown that the final temperature is always 1% lower than the set value, the maximum effective temperature of the element can be decreased by 1%.

Once the parameters have been calculated, the 'Set Parameters' button needs to be pressed, so they and the thermal regime are recorded in the microcontroller's EEPROM.

The load can now be run in the desired regime. Three choices are available, two operating under PC control and one stand-alone.

In the PC mode, the PC calculates the required duty cycle and sends it to the controller, which pulses the load and sends the current temperature value back to the PC to be displayed.

In stand-alone mode, the controller runs its own algorithm to calculate the duty cycle but still sends temperature values to the PC. In this mode the PC can be disconnected at any time with no effect on system operation. Both modes can be terminated using the 'Abort' button.

The third mode of operation does not require the participation of a PC at all. The digital thermometer and controller are used to run the thermal regime already stored in the controller EEPROM.

This mode is initiated by pressing the temperature set button on the digital thermometer for at least 1/2 second. If this button is held down for longer than two seconds,

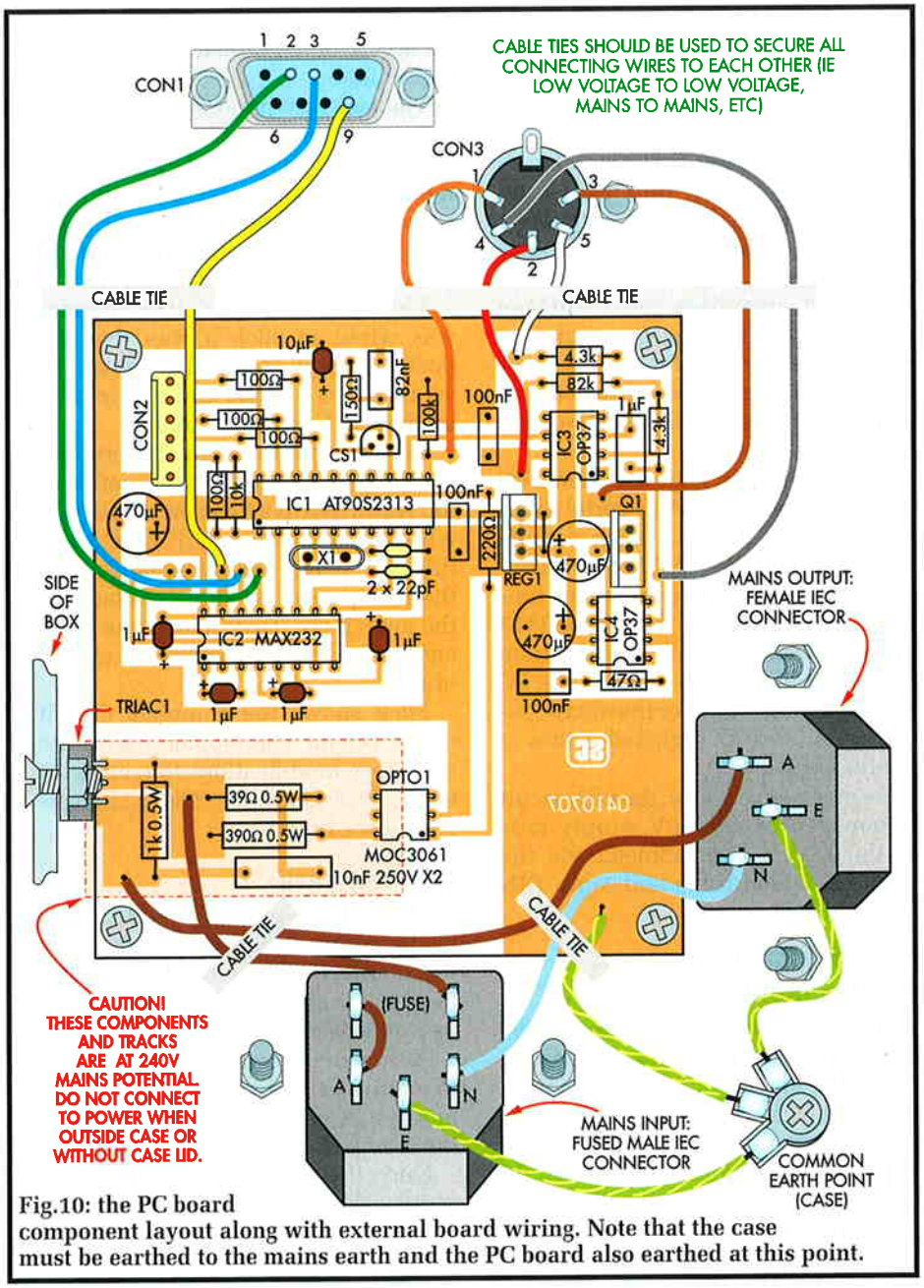

Fig.10: the PC board component layout along with external board wiring. Note that the case must be earthed to the mains earth and the PC board also earthed at this point.

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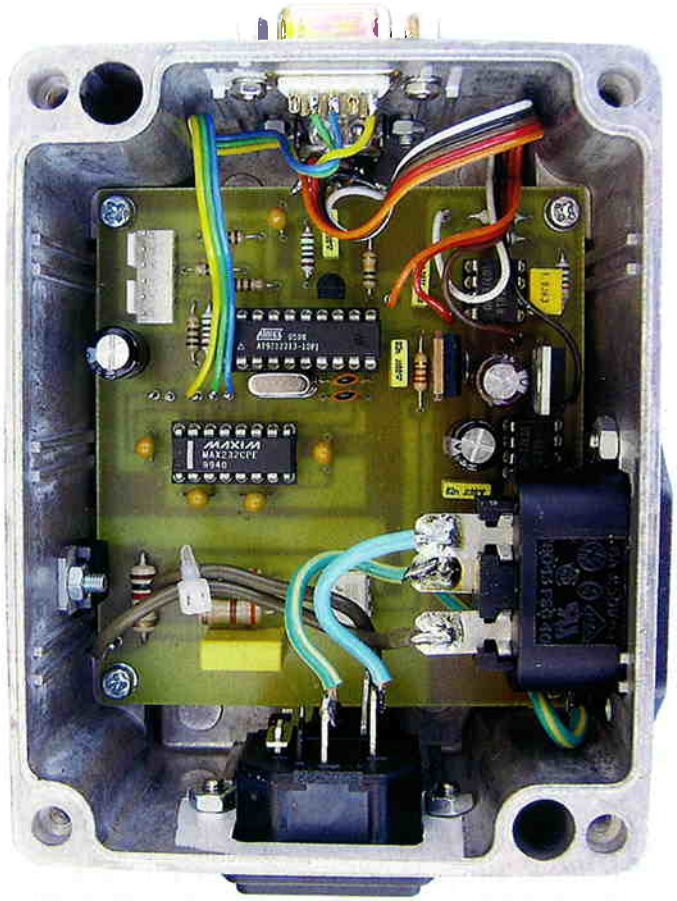


Here's how it fits together in the diecast case as per the diagram at left. Not shown here are the cable ties used to prevent wires moving and shorting. The photo below right shows the completed project.

an additional feature is turned on, whereby rather than using the set temperature stored in memory as the first set temperature value, the controller reads the temperature set on the digital thermometer and uses it instead.

This mode is terminated, either when the time stored in memory elapses or the thermometer is turned off.

Construction

All the components of the PID Temperature Controller are mounted on a PC board measuring 85.5 x 79mm and coded 04107071, which itself is mounted in a weatherproof aluminium diecast case measuring 115 x 55 x 90mm (eg, Jaycar HB-5042).

The complete wiring diagram is shown in Fig.10. An accompanying photo shows the wiring layout of the prototype which is slightly different to that shown in Fig.10.

The diecast case needs to be drilled to accept an IEC male mains socket which contains an integral 250V 10A slow-blow fuse, an IEC female mains socket, as well as 5-pin DIN and RS232 sockets.

The required cut-outs for the IDE sockets (male and female) can be made either by drilling around the periphery with a small drill and filing out, or by using a mill if one is available.

Two holes need to be drilled to accept the 3mm screws which affix the isolated Triac and mains earth wire lug.

Assembly of the PC board is quite straightforward but we can suggest a procedure.

Install the PC pins, sockets and connector CON2 first, then the passive components such as resistors and capacitors, followed by the link and 4MHz crystal. Next are the 3-terminal regulator, transistor Q2 and the op amps, current source (LM336) and the optocoupler. Ensure that the 1µF and 10µF Tantalum capacitors are connected with the correct polarity.

The Triac should be soldered to the PC board, keeping its leads as short as possible, while still allowing them to be cranked slightly, so that its insulated tab can be secured to the case.

The entire mains section of the track needs to be 'tinned' with a layer of solder about 1mm thick, to reduce PC board heating when high-power loads are being controlled. Use a 40W soldering iron or higher for this.

Once the diecast case has all holes drilled and machined, the IEC male and female power sockets can be installed, then the 5-pin DIN socket and 9-pin D socket.

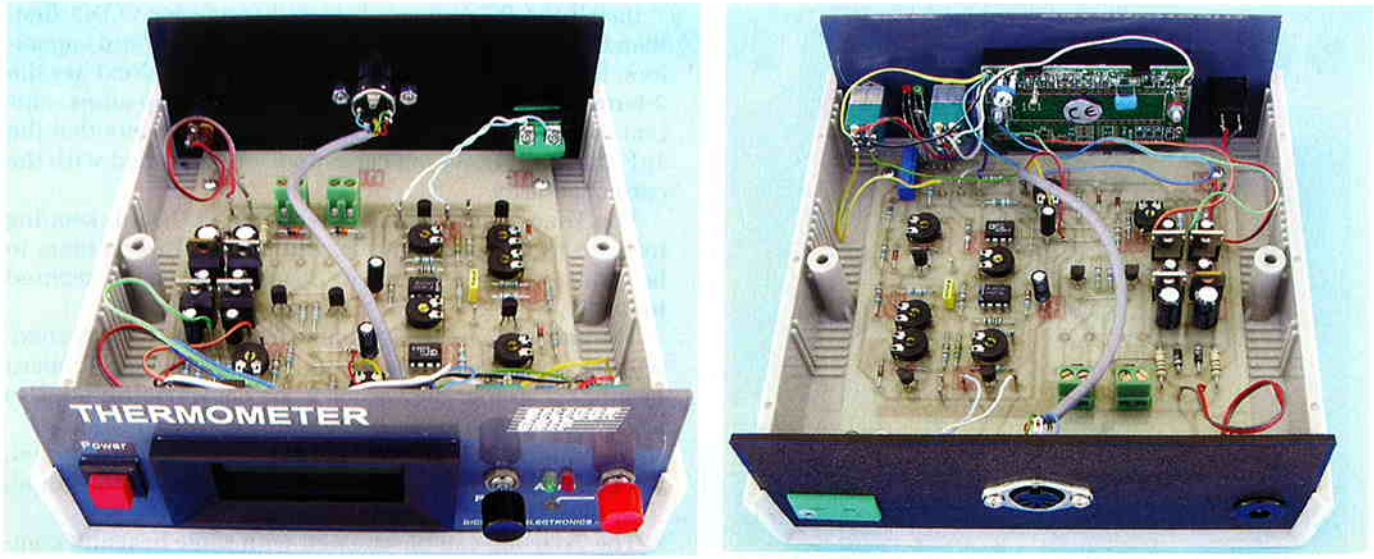
The Triac tab can be smeared with some heatsink compound and the assembled PC board mounted in the case, using the four corner mounting holes pre-drilled in the box. Secure the Triac tab to the case, using a screw, nut and lockwasher, then connect the mains wiring between the two IEC sockets and to the PC board.

A separate lug-terminated earth mains wire is soldered to the earth contact on the mains socket earth and the lug bolted to the diecast case with a separate screw, nut and lockwasher, as shown in the wiring diagram.

Make sure the mains wiring is as short as possible and is kept well away from the low voltage parts of the circuit.

Once the controller is assembled the digital thermometer needs to be equipped with a DIN socket so that a connection can be made to the controller. This is done by drilling a hole in the back panel (one can use a 1/2" drill and subsequently enlarging the hole with a tapered reamer). The DIN socket is wired as per Fig.10.

Our photos show the Dick Smith Electronics version of the Digital Thermometer which was different in a number of aspects to the original project featured in August 2002. The DSE version had



These photos show the modifications to the Digital Thermometer – the DIN socket on the rear panel allows interfacing to the PID Controller. This is the DSE kit version which is slightly different to the original August 2002 project.

additional 5V regulators for its LCD module and slightly different interfacing to the LCD. However, the connections are still the same.

Operation

Connect the controller to the digital thermometer using a 5-wire DIN cable and to the PC with a 9-way RS232 cable. Turn on the thermometer and check for the presence of +9V & -9V on pins 7 & 4 of either of the two op amps. Check for +5V at pin 20 of the AT90S2313 and confirm that the voltage difference between the controller box and the digital thermometer earth is no more than 1mV or so.

When the unit has passed the above tests, connect an AVR programmer to the programming header and program the microcontroller's FLASH and EEPROM. The software will be available on our website at **www.siliconchip.com.au**

Remove the programming connector and close the box. Connect a suitable resistive load and mains power to the controller and launch the PC application. Choose a suitable COM port number and press 'Test'. If an error message indicates 'no connection', change the COM port number (in the range 1-4) and try again.

If everything is working, the load should be pulsed on/off with a 50% mark-to-space ratio and a graph of the probe temperature-versus-time should appear. You can touch the temperature probe with your fingers and check that the temperature rises and then falls.

Calibration

It is likely that at this stage you will notice some difference between the digital thermometer reading and the temperature displayed on the screen. This is mainly due to variance in the particular values of ADC components in your circuit. Choosing the scaling and offset appropriate to your components can reduce these errors. This is done by pressing the 'Calibrate' button and changing the scalings displayed in the dialog which appears.

You should only do this after you have taken comparative readings of the temperature at two different points and calculated the required changes in the scaling and offset.

Some residual random variation between digital thermometer and screen temperature readings might still be observed after this but it should not exceed a few tenths of a degree. The reason is that the LCD voltmeter in the thermometer averages temperature values over an interval of about one second, whereas the controller reads instantaneous values.

We should also note that the accuracy with which the desired temperature is maintained depends, amongst other things, on the accuracy with which the ambient temperature is measured. If the latter varies during the run, this variation will be reflected in the temperature set by the controller. This is most easily seen by referring to the correspondence in Fig.1.

A change in ambient temperature is equivalent to a change in earth potential, which is reflected in all voltages which are measured with respect to it. To counteract errors introduced in this way, the run should be aborted, a new ambient temperature entered and then operation resumed. SC

Check These Important Safety Points

(1) Use medium-duty hookup wire for the connections between the PC board and connectors CON1 & CON3. **These leads must be kept as short as possible and secured at both ends using Nylon cable ties.** That way, if a lead comes adrift, it cannot move and contact any mains-operated components on the PC board or the terminals of the IEC sockets. *DO NOT* use rainbow cable (as shown in the prototype) – it breaks too easily.

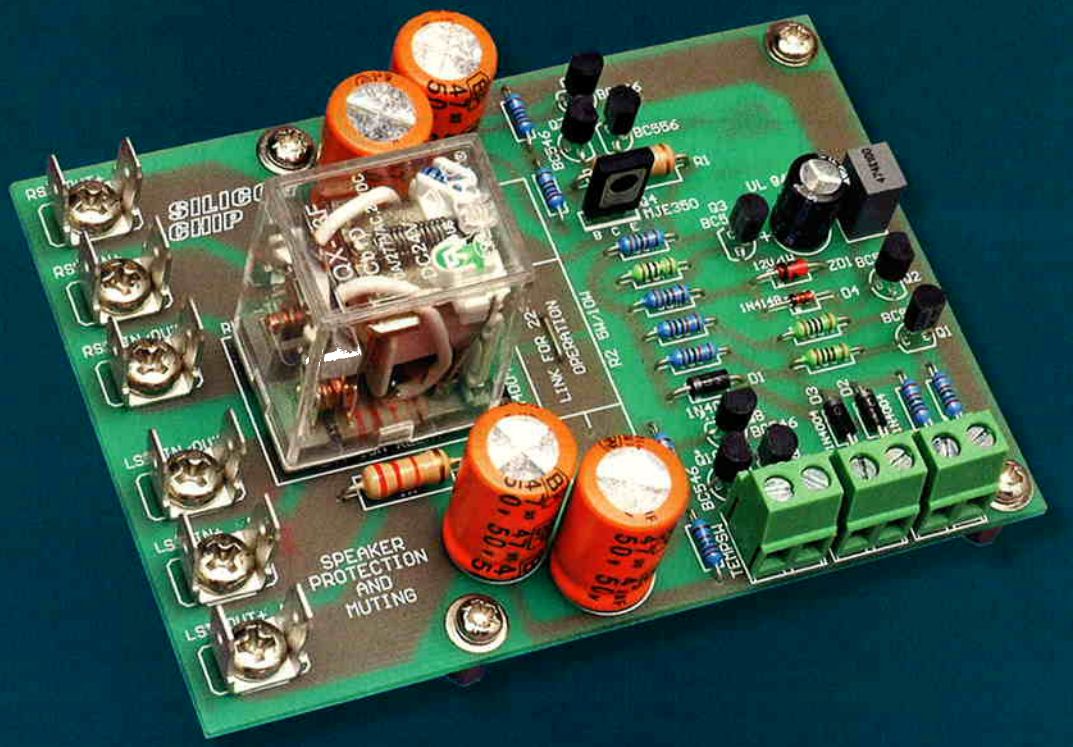
(2) Use mains-rated cable for all connections to the IEC sockets and insulate the terminals using heatshrink tubing. Alternatively, use insulated spade lugs (use a ratchet-driven crimping tool to properly secure the spade lugs to the leads).

(3) Secure the high-voltage wiring between the PC board and the IEC sockets with cable ties. Again, the idea is to make it impossible for any leads to move and contact other parts of the circuit if they come adrift.

(4) Part of the circuitry on the PC board operates at mains potential (as do the terminals of the IEC sockets). Do not touch any part of this circuitry while this device is plugged into the mains. **DO NOT attempt to build this device unless you know what you are doing and are familiar with high-voltage wiring.**

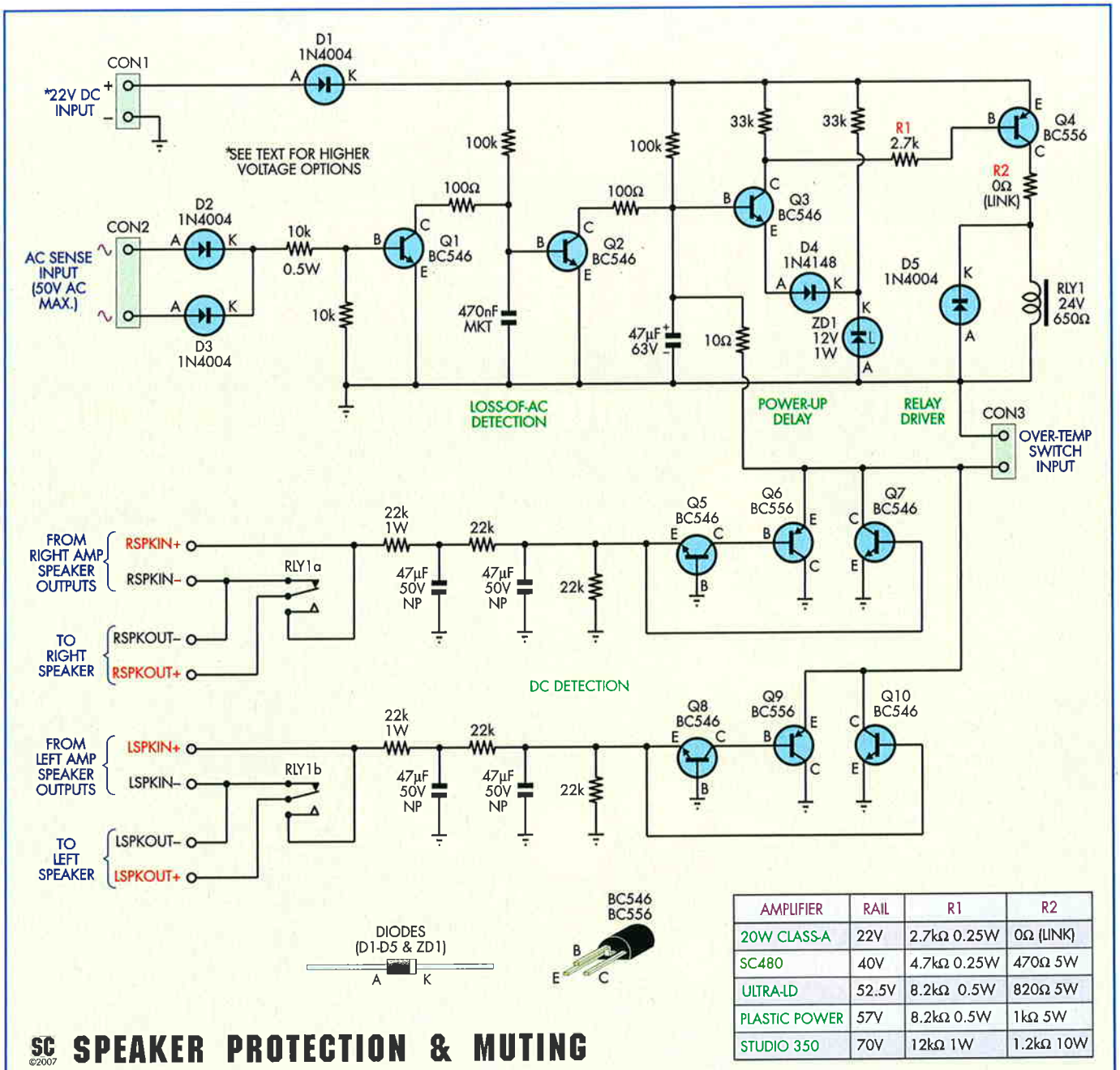
20W Class-A Amplifier; Pt.3

Universal Speaker Protection & Muting Module



Designed for use in our new Class-A Stereo Amplifier, this Speaker Protection & Muting Module is really a universal unit. It can be used with other SILICON CHIP amplifier modules and commercial stereo amplifiers and protects the loudspeakers in the event of a catastrophic amplifier failure. A second function of the unit is to mute the loudspeakers at switch-on & switch-off to prevent thumps.

By Greg Swain & Peter Smith



AMPLIFIER	RAIL	R1	R2
20W CLASS-A	22V	2.7kΩ 0.25W	0Ω (LINK)
SC480	40V	4.7kΩ 0.25W	470Ω 5W
ULTRA-LD	52.5V	8.2kΩ 0.5W	820Ω 5W
PLASTIC POWER	57V	8.2kΩ 0.5W	1kΩ 5W
STUDIO 350	70V	12kΩ 1W	1.2kΩ 10W

SC ©2007 SPEAKER PROTECTION & MUTING

Fig.1: each channel of the amplifier is monitored for DC faults by three transistors – Q5, Q6 & Q7 for the right channel and Q8, Q9 & Q10 for the left channel. If a DC signal is detected, Q3's base is pulled low, turning it off along with Q4 and the relay. Q1 & Q2 provide the switch-off muting feature. If the "AC Sense" input voltage ceases, Q1 turns off, and Q2 turns on which again pulls Q3's base low and turns off Q4 and the relay.

ALTHOUGH DESIGNED specifically for our new Class-A Stereo Amplifier, this unit can actually be used with any audio amplifier with supply rails up to about 70V DC simply by selecting two resistor values to suit.

Basically, the unit provides the following features:

(1) it protects the loudspeakers against catastrophic failure in the amplifier – eg, if an output transistor goes short circuit;

(2) it provides muting at switch-on and switch-off, to prevent thumps from the loudspeakers; and

(3) it provides an input for an over-temperature switch to disconnect the loudspeakers if the output stage heatsink rises above a certain temperature.

Note, however, that this last feature is not used in the Class-A Stereo Amplifier. That's because the heatsinks run hot all the time (about 30°C above ambient) and disconnecting the loudspeakers does nothing to cool them since the output stage in each amplifier module draws a constant 1.12A – equivalent to a power dissipation of just under 50W.

By contrast, disconnecting the loudspeaker from a class-B amplifier im-

This view shows how the unit is mounted in the rear lefthand corner of the Class-A Stereo Amplifier.

mediately reduces the current through the output stage to the quiescent current setting – typically around 50mA (assuming that there's no fault in the amplifier). So for a class-B amplifier, it makes sense to use over-temperature sensing. If the heatsink to which the output transistors are attached gets too hot, disconnecting the loudspeakers immediately reduces the dissipation to just a few watts, which allows the heatsink to cool.

Note that the loudspeakers are connected (and disconnected) using a heavy-duty double-pole relay. We'll have more to say about that later.

Protecting the loudspeakers

By far the biggest reason for incorporating speaker protection into an amplifier is to prevent further damage in the case of a serious amplifier fault. In the Studio 350 Audio Amplifier, for example, the main supply rails are ±70V DC. This means that if one of the output transistors fails and there's no loudspeaker protection, more than 70V DC would be applied to the speaker's voice coil.

In a nominal 8Ω speaker, the voice coil has a DC resistance of around 6Ω and so the power dissipation would be around 800W until the supply fuse blew. In the meantime, this amount of applied DC power is likely to push the voice coil out of its gap, damaging the voice coil and suspension in the process. And if the on-board supply fuse didn't blow fairly quickly (a strong possibility since a current of around 11.7A may not blow a 7A fuse straight away), the voice coil would quickly become red-hot and could set fire to the speaker cone material.

This risk applies to any audio power amplifier of more than about 40W per channel. So a loudspeaker protection circuit is a good idea.

The risk of setting fire to the loudspeaker is nowhere near as great with the Class-A Stereo Amplifier because the supply rails are just ±22V. In this case, a shorted output transistor would result in a dissipation of about 80W in the speaker's voice coil. It might not be enough to cause a fire but it's certainly high enough to damage the loudspeaker – ie, by burning out the voice coil.

Muting the thumps

Muting switch-on and switch-off thumps is another important function of this unit.

Switch-on thumps are eliminated by using a simple circuit to delay the relay from turning on when power is first applied. That way, the amplifier modules are able to power up and settle down before the relay switches on (after about five seconds) to connect the speakers.

By contrast, switch-off thumps are eliminated by using an "AC Sense" input to monitor the secondary AC voltage from the transformer (up to 50V AC max.). When this AC voltage disappears (ie, at switch-off), the circuit switches the relay off in less than 100ms.

This is much faster than simply relying on the collapsing DC supply rail to turn to the relay off. In practice, this could take half a second or more as the main filter capacitors discharge – more than long enough for a any switch-off thumps to be audible.

Circuit details

Refer now to Fig.1 for the circuit details. As shown, each channel of the amplifier is connected to the NC & NO (normally closed & normally open) contacts of a relay. The relay wipers and NC contacts then each respectively connect to the positive and negative loudspeaker terminals.

Each channel of the amplifier is monitored for DC faults by a triplet of transistors – Q5, Q6 & Q7 for the right channel and Q8, Q9 & Q10 for the left channel. We'll describe the operation of the right channel only, as the circuit for the left channel is identical.

As shown, the active signal from the amplifier's right channel is fed to a low-pass filter consisting of three 22kΩ resistors and two 47µF 50V bipolar (BP

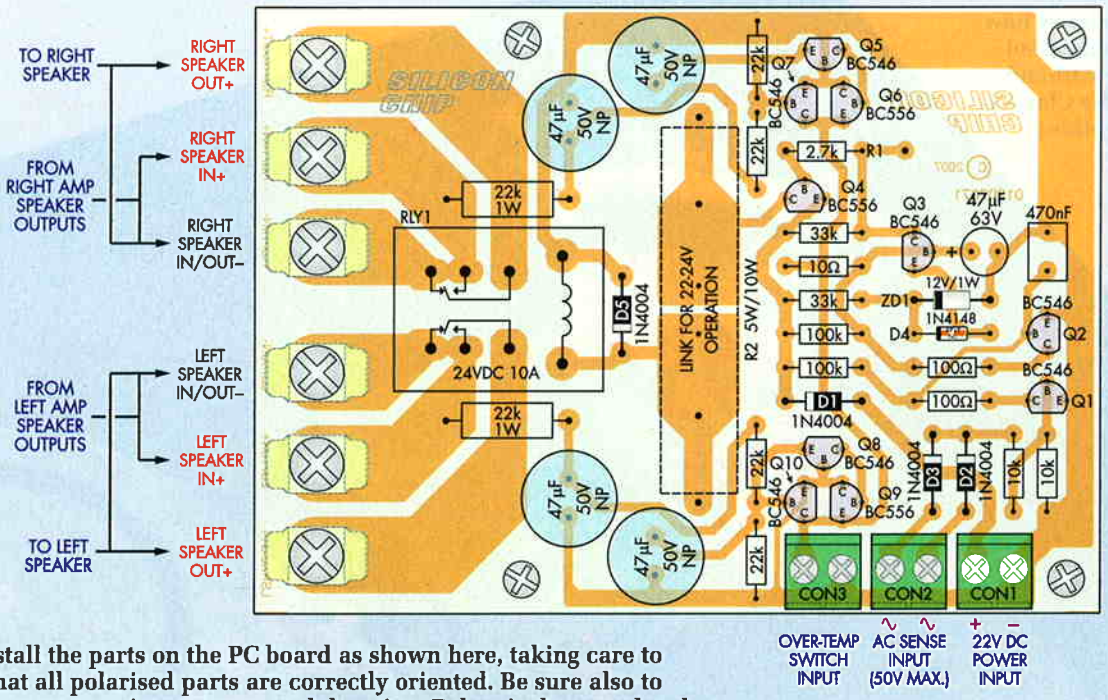
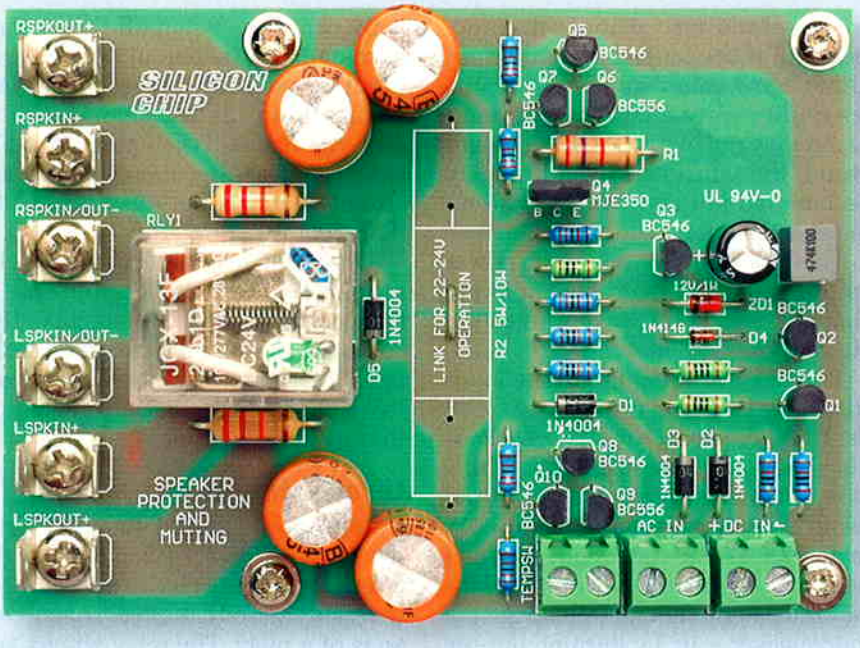


Fig.2: install the parts on the PC board as shown here, taking care to ensure that all polarised parts are correctly oriented. Be sure also to use the correct transistor type at each location. Below is the completed PC board.



or NP) electrolytic capacitors. This network removes any audio frequencies and just leaves DC (if present under fault conditions) to be monitored by the three transistors. This is done because we don't want audio signals to trip the protection circuit.

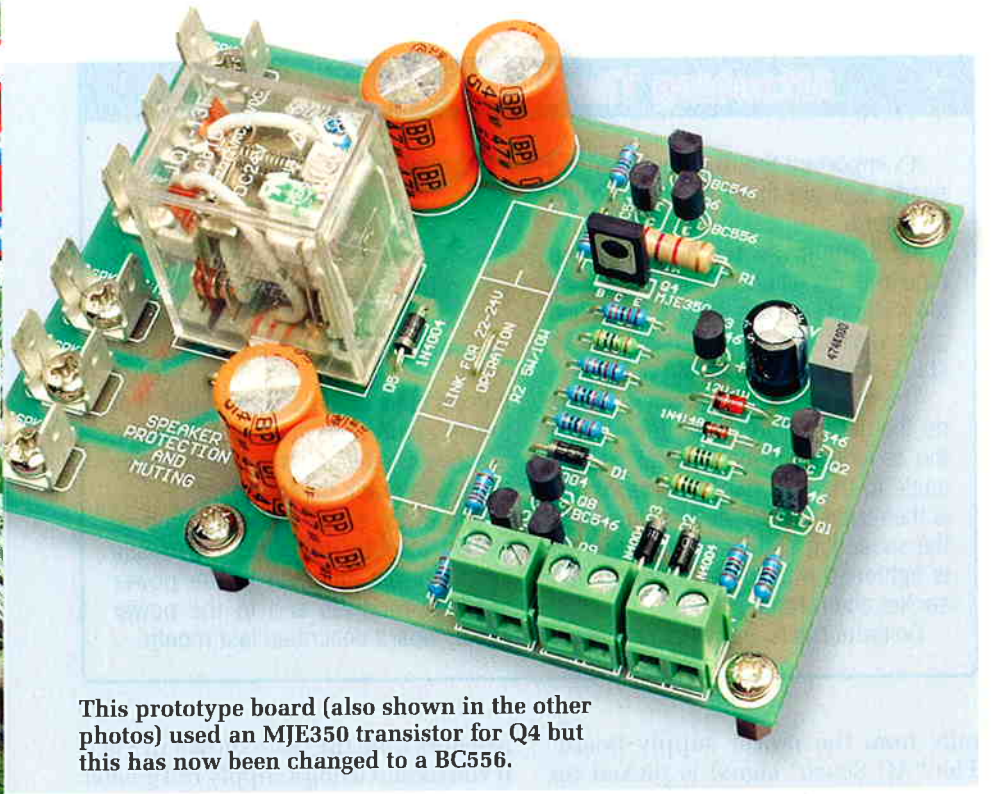
The low-pass filter output is connected to the emitter of Q5 and to the base of Q7. Q5 monitors the amplifier output for negative DC signals while Q7 monitors for positive DC signals.

In operation, transistor Q7 turns on if a DC signal of more than +0.6V is present on its base. Similarly, Q5 turns on if a DC signal of more than -0.6V is present on its emitter. This in turn pulls transistor Q6's base low and so Q6 also turns on.

Normally, in the absence of any amplifier faults, transistors Q5-Q7 are all

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	2	100kΩ	brown black yellow brown	brown black black orange brown
❑	2	33kΩ	orange orange orange brown	orange orange black red brown
❑	4	22kΩ	red red orange brown	red red black red brown
❑	2	22kΩ 1W, 5%	red red orange gold	not applicable
❑	2	10kΩ	brown black orange brown	brown black black red brown
❑	1	2.7kΩ	red violet red brown	red violet black brown brown
❑	2	100Ω	brown black brown brown	brown black black black brown
❑	1	10Ω	brown black black brown	brown black black gold brown



This prototype board (also shown in the other photos) used an MJE350 transistor for Q4 but this has now been changed to a BC556.

off and Q3 is biased on via the 100kΩ resistor connected between its base and the positive supply rail (ignore Q1 & Q2 for the time being). As a result, Q3 pulls Q4's base down (via resistor R1) to just over 12.6V, as set by diode D4 and zener diode ZD1, and so Q4 and relay RLY1 are also on.

Now let's consider what happens if an amplifier fault condition results in DC being present at its output. In this case, either Q6 or Q7 turns on and pulls Q3's base low via a 10Ω resistor. And when that happens, Q3, Q4 and the relay all immediately turn off, disconnecting the speakers.

Diode D5 protects Q4 by quenching any back-EMF spikes that are generated when the relay is switched off.

Transistors Q8, Q9 and Q10 monitor the left channel of the amplifier and they switch Q3, Q4 and the relay in exactly the same manner.

Relay specifications

The relay selected for the job is a 24V DPDT type with contacts rated at 10A. There are two reasons for this high contact rating. First, we want the contact resistance in the relay to be as low as possible so that it has negligible effect on the amplifier's performance, as regards to distortion, damping factor and so on.

Second, the relay contacts have to pass and break the heavy DC current which would otherwise flow through the loudspeaker if a fault occurs in the amplifier. However, we don't merely use the relay to disconnect the amplifier's output from the speakers. If we simply did this, it's possible that the contacts would just arc across and so the heavy DC current would continue to flow through the loudspeaker.

That might seem unlikely but when you have a heavy DC current and a high DC voltage pushing it along, it can be quite hard to break the circuit. This problem is solved by shorting the moving relay contacts to the loudspeaker ground lines (via the otherwise unused NC contacts) when the relays turn off. This diverts the arc current to chassis and ensures that the fuses blow on the amplifier.

By the way, the relay specified in the parts list (ie, the Altronics S-4313) has an in-built green LED that lights when the relay turns on. It's a nice feature that lets you quickly check the status of the relay during testing but is not really necessary.

Muting delay at switch-on

Muting at switch-on is achieved using a delay circuit. This consists of the 100kΩ resistor and the 47µF capacitor connected to Q3's base, along with diode D4 and zener diode ZD1.

When power is first applied, the 47µF capacitor is discharged and Q3's base is held low. As a result Q3, Q4 and the relay all remain off. The 47µF capacitor then charges via the 100kΩ resistor until, after about five seconds, it reaches 13.2V. This now forward biases Q3 which then turns on Q4 and the relay to connect the loudspeakers. This is more than sufficient time for the amplifier modules to settle down and achieve stable operating conditions.

Why 13.2V on Q3's base? Well, that's the sum of the voltages across ZD1, diode D4 and Q3's base-emitter junction when the transistor is on.

Switch-off muting

Transistors Q1 & Q2, together with diodes D2 & D3, provide the switch-off muting function.

D2 & D3 rectify the AC voltage that's fed to the "AC Sense" input (at connector CON2) from a transformer secondary winding (up to 50V AC max.). Provided this AC input voltage is present, the rectified output forward biases Q1 and so keeps it turned on. This in turn holds Q2's base low and so Q2 is off and Q3 functions normally.

The 100kΩ resistor and the 470nF capacitor form a time constant that's long enough to ensure the Q2 remains off when Q1 very briefly turns off during the AC zero crossing points.

However, if the AC signal ceases (ie, at switch off), Q1 immediately turns off and Q2 turns on and quickly discharges (within a millisecond or so) the 47µF timing capacitor via a 100Ω resistor. As a result, Q3, Q4 and the relay all turn off and the loudspeakers are disconnected, effectively eliminating any switch-off thumps.

Over-temperature input

Connector CON3 is the temperature sensor input. It relies on the use of a normally-open (NO) thermal switch that's normally bolted to the heatsink used for the amplifier's output transistors.

Basically, this input is wired in parallel with transistors Q6 & Q7 (and Q9 & Q10) and it controls transistor Q3 is exactly the same manner.

When the temperature reaches a preset level (set by the switch itself), the contacts inside the thermal switch close and pull Q3's base low via the associated 10Ω resistor. As a result, Q3 turns off and this switches off Q4 and the relay.

When the heatsink subsequently cools down, the thermal cutout opens

Parts List

1 PC board coded 01207071, 112.4mm x 80mm
1 10A 24V DPDT PC-mount relay (Altronics S-4313)
3 2-way 5mm or 5.08mm pitch terminal blocks (CON1-CON3)
4 M3 x 10mm tapped spacers
4 M3 x 6mm pan head screws
6 M4 x 10mm pan head screws
6 M4 flat washers
6 M4 shakeproof washers
6 M4 nuts
6 6.3mm double-ended 45° or 90° chassis-mount spade lugs (Altronics H-2261, Jaycar PT-4905).
0.7mm diameter tinned copper wire for link

Semiconductors

7 BC546 NPN transistors (Q1-Q3, Q5, Q7,Q8 & Q10)
3 BC556 PNP transistors (Q4, Q6 & Q9)
4 1N4004 diodes (D1-D3, D5)
1 1N4148 diode (D4)
1 12V 1W zener diode (ZD1)

Capacitors

1 47µF 63V PC electrolytic
4 47µF 50V non-polarised (bipolar) electrolytic (Altronics R-6580, Jaycar RY-6820)
1 470nF 50V metallised polyester (MKT)

Resistors (0.25W, 1%)

2 100kΩ	1 10kΩ 0.5W
2 33kΩ	1 2.7kΩ
4 22kΩ	2 100Ω
1 10kΩ	1 10Ω

2 22kΩ 1W 5%

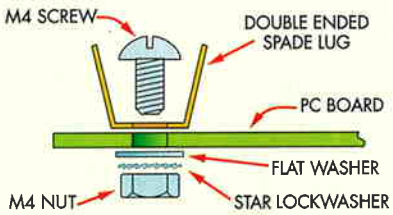
Attaching The Spade Connectors

It's important that the double-ended spade lugs are fitted correctly to the PC board.

Fig.3 (right) shows how they are mounted. Each lug is secured using an M4 x 10mm screw, a flat washer (which goes against the PC board pad), an M4 star lockwasher and an M4 nut.

The trick to installing them is to first do the nut up finger-tight, then rotate the assembly so that it is at a right-angle to the PC board. A screwdriver is then used to hold the M4 screw and the spade lug stationary while the nut is tightened from below using an M4 socket and ratchet.

Do the nut up nice and tight to ensure a good connection and to ensure that the assembly does not rotate. Don't be too heavy-handed though, otherwise you could crack the PC board.



The exact same mounting method should also be used for the spade lug terminals attached to the power amplifier modules and to the power supply board described last month.

again and Q3, Q4 and the relay turn on again to reconnect the loudspeakers.

As previously stated, the over-temperature sense feature is not used with the Class-A Stereo Amplifier because the heatsinks run hot all the time and disconnecting the loudspeakers does nothing to cool them.

Power supply

Power for the Loudspeaker Protection circuit is derived from a suitable DC rail within the amplifier. This can range anywhere from about 20V DC up to 70V DC.

In the case of the Class-A Stereo Amplifier, we use the +22V and 0V rails from the power supply board. The "AC Sense" signal is picked up directly from the AC terminals on the bridge rectifier (more on this in a future issue).

Note that the values shown for R1 & R2 on Figs.1 & 2 assume a 22-24V supply rail. If the available DC supply rail is higher than this, then resistors R1 and R2 must be changed accordingly to ensure a base current of about 3-5mA for Q4 (as set by R1) and to ensure that no more than about 24V DC is applied to the relay (R2). In the latter case, it's just a matter of selecting R2 so that the relay current is about 37mA (assuming that the relay has a coil resistance of about 650Ω).

The table included with Fig.1 shows resistor values to suit the supply rails used to power the SC480, Ultra-LD, Plastic Power and Studio 350 power amplifier modules.

Construction

The parts for the Speaker Protection & Muting Module are all mounted on a PC board coded 01207071. Fig.2 shows the assembly details.

Mount the resistors and diodes first, taking care to ensure that the diodes are all oriented correctly. Table 1 shows the resistor colour codes but you should also check each resistor using a digital multimeter before installing it, just to be sure.

Install a 2.7kΩ 0.25W resistor for R1 and a link for R2 if you are building the unit for the Stereo Class-A Amplifier. Alternatively, select these resistors from the table shown in Fig.1 if you intend using a supply rail greater than 24V.

If the supply rail is between the values shown in the table, then simply scale the resistor values accordingly and use the nearest preferred value.

The six double-ended spade lugs for the speaker input and output terminals are next on the list. These are attached using M4 x 10mm screws, flat washers, star washers and nuts – see Fig.3.

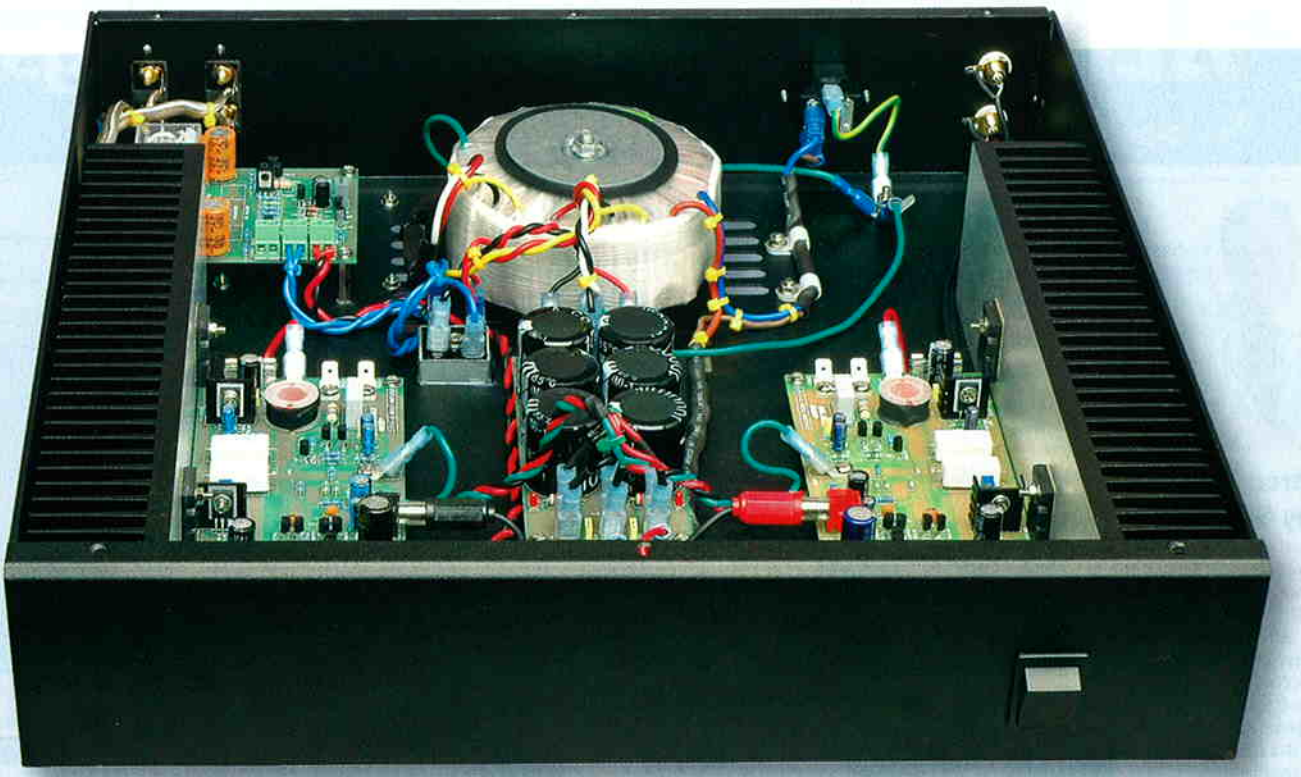
Note that, ideally, the double-ended spade lugs supplied should be 90° types. However, if you are supplied with 45° types, just bend the lugs to 90° before installing them on the board.

The transistors, the electrolytic capacitor and the bipolar capacitors can now be installed, taking care to ensure that the correct transistor type is fitted to each location. The four 47µF bipolar capacitors can go in either way around but watch the orientation of the polarised 47µF 63V electrolytic capacitor.

Finally, you can complete the board assembly by fitting the three 2-way terminal blocks and the DPDT relay.

Testing

If you have a suitable DC supply, you can test the unit prior to installing it. To do this, first connect the supply to screw terminal block CON1 and install a wire link between one of the CON2 "AC Sense" input terminals and the positive supply rail (this is done to ensure transistor Q1 turns on). Do not connect anything to the temperature



Making progress – inside the partially completed amplifier. Yet to be fitted is the preamplifier and remote volume control circuitry which will now all be on one PC board (details next month).

switch input or to the speaker terminals at this stage.

Next, apply power and check that the relay turns on after about five seconds. If it does, temporarily short the temperature switch input – the relay should immediately switch off.

Similarly, the relay should immediately switch off if you disconnect the link to the "AC Sense" input.

Temperature Sensors

Temperature sensors are variously called "thermostat switches", "thermal cutouts" and "thermal circuit breakers" and are available in a range of trip temperatures from 50-100°C. **Note that the temperature sensor used with this unit must be a normally open (NO) type.**

Both NO and NC (normally-closed) temperature sensors are available from Altronics and Jaycar Electronics.

Assuming it all works so far, the next step is to check that the relay switches off if a DC voltage is applied to the loudspeaker terminals (this simulates an amplifier fault condition). To do this, apply power, wait until the relay switches on, then connect a 1.5V battery (either way around) between the ground terminal of CON1 and the LSPKIN+ terminal. The relay should immediately switch off.

Repeat this test for the RSPKIN+ terminal, then reverse the battery polarity and perform the above two tests again. The relay should switch off each time the battery is connected.

Note that we don't connect to the LSPKIN- or RSPKIN- terminal for this test because these two inputs are fully floating at this stage. That changes when the Speaker Protector module is installed in a chassis and the loudspeaker leads connected, because the negative loudspeaker terminals on the amplifier are connected to chassis (via the power supply).

Troubleshooting

If the relay doesn't activate when power is first applied, switch off immediately and check for wiring errors – eg, incorrect supply polarity, a transistor in the wrong location, etc. If this doesn't locate the fault, switch on and check the supply voltage, then check the voltages around the transistors. Q3's emitter should be at about 12.6V and its collector at 12.8V, while both Q3 and Q4 should have base-emitter voltages of 0.6V.

Similarly, Q1 should have a base-emitter voltage of 0.6V (provided the link between the "AC Sense" Input and the positive supply terminal is in place) but the other transistors (Q2 & Q5-Q10) should all be off – ie, they should have base-emitter voltages of 0.2V or less.

If Q3's base voltage is low (around 0.2V), then it could mean that Q2 is on and Q1 is off, possibly due to no voltage being applied to Q1's base. Alternatively, one of the transistors in the speaker input monitoring circuits (ie, Q5-Q10) could be faulty (short circuit). You can quickly isolate which circuit section is at fault by disconnecting the 10Ω and 100Ω resistors to Q3's base.

Just remember that all transistors that are turned on will have a base-emitter voltage of about 0.6V. This should enable you to quickly locate where the trouble lies.

That's all for now. Next month, we'll describe the low-noise Preamplifier & Remote Volume Control Module. SC

JULY '07

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Clean the tiniest of items without harsh solvents!

Even delicate items such as jewellery or automotive parts. This cleaner uses water and household detergent, coupled with ultrasonic waves to clean even the tiniest of items without damage. Features a 154 x 95 x 48mm stainless steel tank and a handy 1.5 to 8 minute digital timer. Also includes tank basket & watch attachment.

Gently cleans computer connectors, PCBs, jewellery, glasses, DVD's, watches, fuel injectors and other very fine parts.

ALTRONICS ONE-STOP ELECTRONICS SHOP

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Perth WA: 174 Roe St Auburn NSW: 15 Short St Springvale VIC: 891 Princes Hwy

Your One-Stop Power Shop...

Regulated precision for voltage critical applications

25A High Current Regulated Power Supply

$265 M 8224 RRP $309

Compact switchmode design is both powerful and lightweight. Great for powering communications equipment, car audio amplifiers, camping fridges or other portable DC power appliances. Precision and quality in the one unit! 3 to 15V regulated @ 25A max. 220 x 110 x 220mm

SAVE $70!

Professional Dual Tracking Power Supply

$429 M 8226 RRP $499

3 POWER SUPPLIES IN ONE 2 x 0-30V 3A PLUS Auxiliary 1.5-6V 5A output!

Superb quality power supply for testing, repairing or R&D on complex equipment with split voltage rails. Built-in digital volt & current meters for precision accuracy. Supplies can operate independently, in series, or parallel. • Overload & short circuit protected • Excellent regulation • Floating outputs • 379 x 135 x 280mm

12V SLA Charger

Compact, easy to use with trickle charging function. Suits 12V SLA batteries up to 7.2Ah. 300mA charge current.

Connects in just seconds!

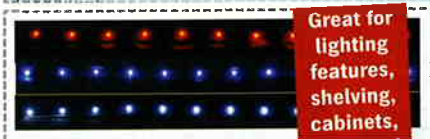
$19 M 8520 RRP $24.95

Sealed Lead Acid Batteries

Great for security, solar power systems, UPS, comms gear etc.

Premium quality for long life.

	Rating	Normally	Now
S 5075B	1.3Ah 12V	$19.50	$15
S 5080	3.3Ah 12V	$24.95	$20
S 5090B	7.2Ah 12V	$36.50	$28
S 5098	12Ah 12V	$45	$39
S 5100	20Ah 12V	$55	$45
S 5104	26Ah 12V	$69	$55
S 5113	40Ah 12V	$115	$95



Great for lighting features, shelving, cabinets, steps etc!

Easy feature lighting for your home or car!

These flexible LED strip lights can be ganged together to form extravagant lighting schemes in your home, car, boat, caravan etc. Operating from 12V DC, each 300 x 10mm strip features 12 high brightness LED's. Up to 80 strips can be ganged together via easy pin header connections. Power supply cable included with each strip. Rated at IP64 for a high level of protection from moisture and dust.

$14.50 X 2550 Strip RED!
$8.95 X 2560 Corner

$16.95 X 2554 Strip BLUE!
$8.95 X 2564 Corner

$21.90 X 2555 Strip WHITE!
$8.95 X 2565 Corner

To select an appropriate 12V power supply, simply add up the current draw of the number of strips and corner sections your installation requires: 300mm strips 75mA, Corners 20mA. ie: 4 strips and 4 corners equals 380mA current draw.

Mini 12V Bulkhead Halogen Light

This handy 12V bulkhead light is ideal for installation in custom cabinets. Great as a bedside reading light, for cooking areas etc. Features on/off switch and adjustable light angle. Includes 10W MR11 globe, spares $9.95ea (X2020A). 80Ø x 45H mm.

Great for service vans!

$10.95 X 2400 NEW!

3W LED Lights

Low heat, high efficiency!

Direct replacement for MR-16 halogen globes. Provides up to 100,000 hours of life, much more than ordinary halogens. Powered off a standard halogen transformer. 3W light output, 5W power consumption. 12-24V AC/DC operation. (note: switchmode transformers may require up to 4 LEDs per circuit to operate.)

$60/pr X 2200A Cool White X 2206A Warm White RRP $44.95ea

Ultra Compact 4 x AA Battery Charger

Take advantage of rechargeable batteries and save a heap! Suits NiCad or NiMH type batteries. Charges 2 or 4 AA batteries to full capacity overnight!

*Batteries not included.

Plugs directly into a power point, no messy cords!

$10 A 0285 RRP $14.50

Powerful AA Rechargeable Batteries

Good for up to 1000 recharges. You can recoup the cost of these high quality rechargeable batteries in just 3 or 4 uses! Sold in packs of 4.

Less than 1¢ per use cycle!

4 batteries per pk	1 Pack	2 Packs
S 4749 AA 2600mAh	$19.95	$35

7 Day Digital Timer

Save on your power bill by automating appliance activations around the home. Each day can switch on and off up to 10 times! Easy to program, it also features a random holiday mode to help reduce the risk of burglary whilst away. Inbuilt countdown timer is especially useful for heaters and fans.

$24.95 X 8018 NEW!

Reduce power usage around your home or workshop!

Mechanical 24 Hr Mains Timer

GREAT VALUE!

Save power and switch appliances off at night automatically with this easy to use timer. Appliances may be switched on and off multiple times per 24 hours as required!

$9.50 X 8010 NEW!

High Current DC Plugpacks

SAVE OVER 30% Supplied with 2.1mm DC jack. M 8909-34 slimline case pictured.

BARGAIN PRICES!

Switchmode Plugpacks	RRP	NOW
M 8909 5VDC @ 2.6A	$22.90	$15
M 8925 9VDC @ 1.7A	$22.90	$15
M 8934 12VDC @ 1.5A	$22.90	$15
M 8935 12VDC @ 2.5A	$27.50	$22

Multi-Voltage Power Pack

Up to a whopping 5A! Great for appliances with high current draw such as comms/IT equipment. Selectable voltages: 5, 7.5, 9, 12, 13.5, 15V. Output at 13.5 & 15V settings ≈3.8A. **Includes 6 appliance tips!**

$39 M 8987 RRP $49.95

20% OFF!

Charge your laptop in the car!

This compact supply simply plugs into your cars accessory socket and provides regulated power to a laptop. Selectable output voltages 15, 16, 18, 19, 20, 22 and 24VDC, up to 3A (M 8626) or 6A (M 8627). Supplied with 6 adaptors to suit most laptops.

$39 M 8627 6A RRP $49

$35 M 8626 3A RRP $44.95

6A model suits new Sony Vaio, Dell & NEC laptops!

Multi Voltage Car Power Supply

Great for powering anything portable in the car. Keeps the kids game units powered up on those long road trips! Simply plugs into your cigarette lighter socket. 12V 1.5A max.

$15 M 8620 RRP $22.95

Includes 7 tips for a multitude of appliances!

Super compact solar panel, just 35x13cm

Keep your car battery in top condition.

Tired of forking out a fortune for batteries when you leave your car or boat sitting for a few weeks? This solar trickle charger keeps your battery in top condition, even over long periods of inactivity. ≈100mA charge rate. Connects via car accessory socket or croc clips. *Will not charge dead flat batteries.

$30 N 0700 RRP $33

Extend the life of your car, caravan or boat battery

150A Electronic Battery Isolator

$149 N 2102 RRP $169

For dual battery systems in 4WD's. Allows you to connect a load off one battery whilst ensuring your second battery remains fully charged so the engine can be started. Features a handy charging circuit and full electronic isolation for use in modern cars.

Auto Accessory Socket

NEW!

Great for 4WD's & caravans. Easy to build into cabinets for quick and easy appliance connection. 12V cig. socket.

$9.95 P 0654 NEW!

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Express Order Hotlines

Phone: 1300 797 007 Fax: 1300 789 777 www.altronics.com.au

ALTRONICS ONE-STOP ELECTRONICS SHOP

Order Hotline 1300 797 007

Portable Digital Storage Oscilloscope

Perfect for field servicing!

Combines the functionality of a 2 channel digital storage oscilloscope and an isolated true RMS 6000 count multimeter, in one compact hand held device! High speed USB connectivity provides easy uploading of data to a PC for analysis. **Supplied complete with test leads, scope probes, temperature probe, AC adaptor, carry case and holster. Specs:** • 20MHz or 60MHz bandwidth models • 200ms sampling rate • Cat III rated • Temperature, humidity, air pressure measurement • Dual mode voltage & wave shape display • Easy menu driven operation • Q 0110 AC clamp meter adaptor $119 • *See website for more info on these fantastic hi-tech portable test & analysis units.*

SAVE UP TO $245!

$1450 Q 0103 60MHz RRP $1695

$1100 Q 0101 20MHz RRP $1295

Contact Free Digital Thermometer

...with laser guided beam!

Lightweight, point and shoot temperature measurement. Provides accurate temperature readings from a distance. Ideal for temperature measurement in dangerous places, or when equipment is operating. -30°C to 550°C.

As reviewed by Farming Ahead magazine, shown to have the greatest temperature accuracy out of 9 models tested!

$99 Q 1290 RRP $125

WATERPROOF Autoranging DMM

SAVE 20%

Splash and dust proof, rated at IP67! Perfect for use in harsh outdoor environments. A dependable, durable and versatile piece of test gear. Ideal for marine or mining technicians.

Features: • Jumbo LCD • Frequency counter • Temp measurement • Capacitance • 10A current range • Includes thermocouple • Max/min data hold

$119 Q 1088 RRP $149

Pro Grade Test Probes

Superb construction for long service life. Soft silicon rubber construction. Cat 3 1KV 10A approved.

$19.95 P 0407 NEW!

Automotive Circuit Tester

Plugs directly into automotive blade fuse sockets. Quick reliable testing!

$10.95 P 0418 NEW!

FITS RIGHT IN YOUR POCKET!

Multifunction Pocket Tester

$9.95 Q 3000 BARGAIN!

Provides instant checks for: continuity, DC volts presence, microwave oven leakage and locating 240V AC wiring. Provides audible and visual feedback. Batteries included.

21 Range Digital LCR Meter

20% OFF!

This super accurate LCR meter is perfect for developing audio crossovers, switchmode power supplies, resonant filters & RF circuits. Allows quick measurements of inductance, capacitance and resistance. Test leads, carry case and holster included.

$79 Q 1155 RRP $99

600A True RMS AC/DC Clamp Meter

SAVE OVER 20%

Accurately measures AC or DC current to a MASSIVE 600A! A professional quality unit with advanced features such as true RMS AC measurement, resistance, temperature, capacitance, zero & hold functions - All supplied with carry case & test leads. Max input 600V.

Great value for the student and professional alike! An essential for electrical tradespeople & auto electricians.

$120 Q 0966 RRP $155

Precision Frequency Counter

A must have for RF servicing!

This high accuracy counter covers a frequency range of 10Hz to 2.7GHz in two ranges with separate inputs; Ch A 10Hz to 100MHz and Ch B 100MHz to 2.7GHz. Ideal for servicing and calibrating RF equipment such as radio mics, CB and amateur transceivers. **Features:** • 8 digit LED display • High input sensitivity • Period, frequency and pulse count (totalise) functions • x20 input attenuator • Handy inbuilt bench stand

$169 Q 1536 RRP $199

Insulated Screwdrivers

With rubberised grips & chrome vanadium tips!

EN 60900 Approved.

T 2194 kit includes 3 blade, 2 phillips plus 240V tester.
T 1982 4mm blade
T 1984 6.5mm blade
T 1987 #1 phillips
T 1988 #2 phillips

$4.95/ea Drivers NEW!

$19.95 T 2194 6pc Kit NEW!

Precision Driver Set

Ideal for technicians servicing comms gear & hi-tech devices etc.

Features a comfortable driver handle which uses 19 interchangeable, pozi, hex, torx and blade tips.

$15 T 2185 RRP $21.95

Pro quality!

Find the right driver bit for any job!

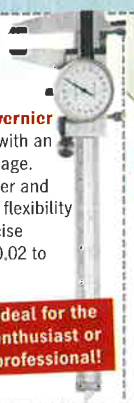
$14 T 2180S RRP $19.90

Jumbo 66pc Driver Set

Special pack includes both T 2180 and T 2182 bit sets.

Includes a massive variety of slotted, pozi, hex, phillips, star, triwing, torx and snake eye bits. Magnetic hex extension bars included.

Measure Precisely



Engineer grade stainless steel vernier calipers. Fitted with an easy read dial guage. Thumbwheel slider and lock allows great flexibility when taking precise measurements. 0.02 to 150mm.

$39.95 T 2245 RRP $44.95

Ideal for the enthusiast or professional!

Ideal for servicing!

$10 T 4020 RRP $14.95

Protect your components from damaging static

Many electronic parts may be damaged by static. This handy mat will keep your work area static free! 55 x 30cm.

Automotive Crimper

No more fumbling with poorly designed crimpers! These pro-quality RATCHET action crimpers are designed to be easy on the hands, and will ensure connectors have a vice like grip. Suits red, blue and yellow kwik connectors / crimp lugs.

PLUS A FREE H 1800 crimp multi pack valued at $19.95!

$46.95 T 1552S HOT PRICE!

Hobbyist Mini Drill Kit

Great for custom projects, auto repairs, modellers and hundreds of other small jobs around the home!

Includes:
4 grinding stone bits, cutting disc, four chucks, 5 PCB drills and plugpack. Powerful motor makes it perfect for customising instrument panels.

$35 T 2301 RRP $59.95

Great for cutting & shaping plastics!

Portable Audio Cable Tester

Allows quick and easy confirmation of cable integrity. Suits 6.35mm jack, 5 pin DIN, RCA, XLR, Speakon & Banana plugs. Steel case is built to withstand the rigours of pro PA use. Also great for AV & CCTV installers. Requires 9V battery.

Save time & frustration tracking down dodgy leads!

$39 Q 2020 NEW!

Test LAN cables FAST!

This ultra compact LAN tester saves you the time and frustration of identifying bad network leads! It instantly displays the status of all cable conductors (shorted pins, straight or crossover cable identification). Suits most common network configurations. Includes battery.

$40 D 3006 RRP $49.95

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No Risk 14 Day Money Back Guarantee

If you are dissatisfied with our goods for any reason, return to our premises within 14 days for a full refund (less transport costs). Returned items must be in NEW condition with all packaging and instructions (less transport costs).

Project Parts & More...

Rugged Steel Push Buttons

GREAT VALUE!

2 for $14
S 0930 - 0937
RRP $8.50ea

With illuminated ring! Stylish round switches with 12V LED illumination. Great for cars, intercoms etc. Alternate or momentary available. All DPDT, 1A @ 24VDC rated.

S 0930 Red Momentary
S 0933 Blue Momentary
S 0934 Red Alternate
S 0937 Blue Alternate

Ideal for building amplifiers, pre-amps, power supplies etc.

Compact & Stylish Rack Cases

Superb quality finish for easy assembly. Tough powdercoated finish with raw (silver) or black anodised aluminium front panel. Rear panel is aluminium for easy customisation to suit your equipment.

$49 H 5031 1U Blk RRP $55
$45 H 5011 1U Raw RRP $49
$59 H 5032 2U Blk RRP $65
$55 H 5012 2U Raw RRP $59

Flat Speaker Cable

For cable runs under carpet, rugs and skirtings!

$55 W 2980 50m RRP $70

This flat whopper cable uses oxygen free copper for superior speaker signal quality. FULL 50m ROLLS.

Great for any hi-fi system!

Heavy duty toggle with LED

$6.95 S 1010 HOT PRICE!

Whopping 30A contact rating (12V). SPST. Ideal for automotive use.

Powertran 300VA Toroidal

LIMITED STOCKS.

What a bargain... Half the price of our regular 300VA transformers, plus the leads are already fitted with crimp connectors for you! High output with 18+18V secondary windings. Primary 240V.

$36 MA5518 RRP $50

Manufacturer quality!

ALSO GREAT FOR 4WD'S & MOTORHOMES!

12V Marine Switch Panels

These handy 3 or 6 way switched distribution panels provide a neat and tidy wiring solution in boats, 4WD's etc.

$49 S 2203 95x133mm NEW!

$75 S 2206 189x133mm NEW!

Each switch is illuminated and features a 15A inline fuse. Includes neoprene gasket & 30 adhesive lexan labels with typical boat & yacht descriptions.

Quality 3 Pin XLR's

40% OFF!

MAKE YOUR OWN MIC LEADS! As used by PA professionals. **Packs of 10.**

$22/10pk P 0802 Male RRP $38.50
$24/10pk P 0800 Fem. RRP $40.50

Bargain Mixed Pot Packs

Great for project builders and experimenters. Dual gang 24mm D shaft (R 2274S) or 40T 9mm PCB mount (R 1928S). 10pc's per pack, mixed values contents may vary.

$5 R 1928S RRP $8

$14 R 2274S RRP $19

Robot Parts

We now stock a wide range of robotics parts for your latest invention or idea!

$17.95 J 0002

Gear, cam and pulley kit. Handy kit contains various sized pulleys (4), gears (8), eccentric cams (2), snail cams (2), pear cams (4). Ideal for drive mechanics experiments!

$17.95 J 0001

Caterpillar track kit. Includes two 28mm wide caterpillar tracks and 8 coloured 40mm "press fit" drive wheels. Great for building your own all-terrain robot!

All the parts you need to start a mechatronic invention of your own!

$17.95 J 0012

Worm drive gearbox. 3-6V. 125 x 3mm shaft. 42:1 reduction ratio.

$10.95 J 0015

Parallel drive gearbox. Keyed output stub shaft. 120:1 reduction ratio. Ideal for slower robotic movements. 3-6V.

$17.95 J 0020

High torque worm drive gearbox. 3-6V. 125 x 3mm shaft. 42:1 reduction ratio.

$11.95 J 0018

Contains a selection of gears and axles. Can create ratios from 4:1 to 256:1. **See website for full details.**

Handheld Television Pattern Generator Kit

(SC June '06)

ATTENTION: AV Installers, Service Technicians, Television Repair People!

Only available at Altronics!

This compact, portable generator creates 9 test patterns which are displayed on any device with a composite video input, ie: projectors, plasma, LCD, CRT televisions etc. These patterns allow diagnosis of commonly found video distortion problems. It fits right in your hand, is easy to build, and is powered by a 9V battery! Great for working on ceiling mounted projectors.

$109 K 2725 RRP $129

Portable PIC Programmer Kit

(SC Sept. '03) This battery powered programmer kit is suitable for: PIC16F and 12F, 16F87X series, 24CXX EEPROMS. Unlike cheaper kits, the Altronics K 9505 includes: ZIF socket, cables and 16F84 PIC chip!

$39 K 9505 RRP $49.95

Also check out our 28 & 40 pin adaptor boards (K 9506 & K 9507) to suit, $24.95 ea.

Sale Ends July 31st 2007

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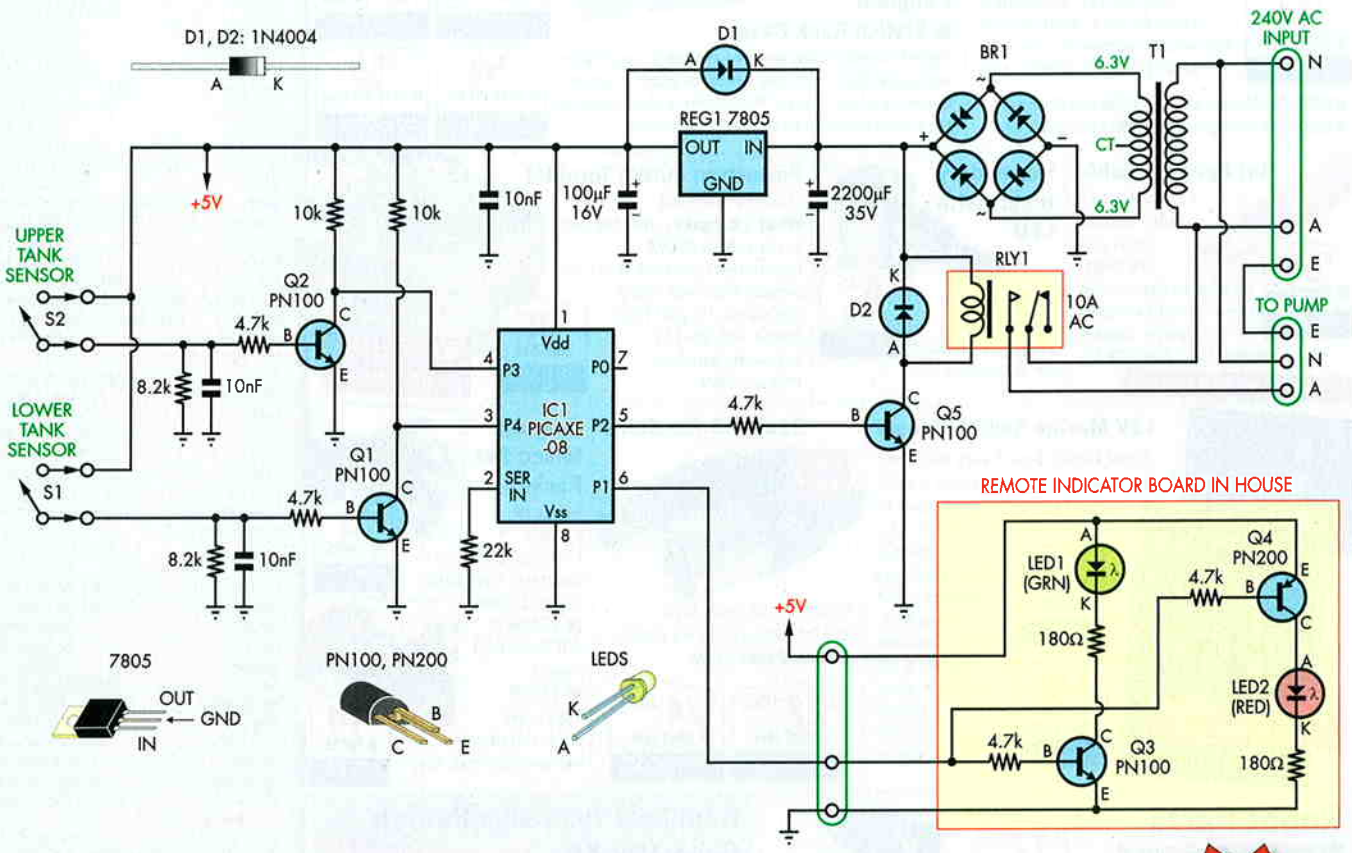
CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions from readers are welcome and will be paid for at standard rates.



PICAXE-based tank pump controller

This circuit was developed to control a pump which transfers water between two large tanks on a steep block in suburban Melbourne. The lower tank receives all the roof water and tops up the top tank via a pump. The top tank then supplies the house.

Both tanks have sensor switches which are open when the water level is low. When the lower tank is empty, its sensor (S1) prevents the pump from switching on by turning off transistor Q1 which means than P4 (pin 3) on IC1 is held high.

The program prevents false triggering due to ripples as the lower tank is filling, as 50 consecutive true values at 100ms intervals have to be counted before the pump is switched on. If any of the 50 counts is false, the counter resets and starts again. This is to prevent the inrush of water to an almost empty tank generating false triggering to start the pump.

When the lower tank has water above the sensor and the upper tank water level is below its sensor (S2), IC1 turns on Q5 and relay RLY1 to switch the pump on. When sensor S2 subsequently closes (ie, when the top tank is full), Q2 turns on and pulls P3 of IC1 low. The pump is then kept on for another 30 seconds to ensure the water level is higher than its switch off point.

The program has a safety cut-off for the pump if it has been running continuously for approximately 30 minutes to guard against a failed tank sensor. If the pump has run continuously for 30 minutes, the pump is stopped and the LEDs alternately flash at a very fast rate so both appear to be on at once. This state requires that the controller must be manually reset by powering off and on after checking for sensor failure. This is to prevent either overflowing the top tank or running the pump dry for an extended period.

Paul Walsh is this month's winner of a Peak Atlas Test Instrument

The pump and its controller are mounted outside (eg, under the house), while the remote indicator is used inside. When the lower (collection) tank is low, LEDs 1 & 2 (green & red) flash alternately at 0.25-second intervals. When the program is detecting the lower tank level, the red LED (LED2) is on. When the pump is on, LED1 is on and when the top tank is full, LED1 is on for 1 second and LED2 is on for 0.25 seconds, alternately.

The top tank has a commercial

Tank Sensor Program

```
'Red LED means water ripple check float sensor
'Green LED means pump is on
'Slow equal flash means lower tank is empty
'Slow green & fast red means top tank is full
'Red & green both appear on means pump on for 30 min needs manual reset,
'possible tank sensor fault

Main:
low 2                                   'pump off
low 1                                   'red LED
if pin3=1 and pin4=0 then Checktt       'TT might be low, LT has water
if pin3=0 then TToff                    'TT full
if pin3=1 and pin4=1 then LToff         'TT is low, LT has no water

Checktt:
wait 1
if pin3=0 then Main                     'check to see if correct

b0=0                                    'reset variable b0 LT low counter
b1=0                                    'reset variable b1 LT Ok counter
b2=0                                    'reset variable b2 10msec counter
b3=0                                    'reset variable b3 25 second counter
do while pin3=1                         'TT is low
findstatus:
    if  pin4=1 then                     'LT is low
            b1=0                        'reset variable b1
            pause 100
            inc b0                      'increment variable b0
            inc b2                      'increment b2
            if b0=50 then LToff         'if variable counts to 20 then exit loop

    elseif pin4=0 then                  'LT is high
            b0=0                        'reset variable b0
            pause 100
            inc b1                      'increment variable b1
            inc b2                      'increment b2
            if b1=50 then runpump       'if variable counts to 20 then run the pump
    endif

    if b2>250 then                      'increment b3 at 25 second intervals
            inc b3
            b2=0                        'and reset 10msec counter
    endif

    if b3=64 then Allstop               'if pump running for 30 minutes then
                                        'stop in case of failure

goto findstatus
runpump:
    b1=0                                'reset variable b1
    high 2                              'pump on
    high 1                              'Green LED on
loop

wait 30
low 2                                   'pump off
if pin3=0 then TToff                    'TT full
if pin3=1 and pin4=1 then LToff         'TT not full, LT has no water

TToff:
high 1                                  'TT full, green LED with fast red flashes
wait 1
low 1
pause 75
if pin3=1 then Main                     'TT not full
goto TToff

LToff:
low 2                                   'pump off
high 1                                  'flash LEDs
pause 250
low 1
pause 250
if pin4=0 then Main                     'LT has water
goto LToff

Allstop:
low 2                                   'pump off
high 1
pause 10                                'fast flash leds both appear to be on
low 1
pause 10                                'requires manual restart
goto Allstop
```

sensor but to avoid having to drill a hole low in the bottom tank, a float sensor was made out of a heavy-duty plastic bottle fitted with a mercury switch and well sealed in silicone sealant. The neck of the bottle and the output lead were connected to a brass weight, sealed with epoxy resin and waterproofed with silicone.

The sensor is forced to float in the horizontal plane by the length of wire set to the minimum water level. As the water rises, the weight inverts the bottle and the mercury switch closes its contacts.

Paul Walsh,
Montmorency, Vic.

Halogen lamp optical pyrometer

You may have observed a blacksmith heat a steel rod to render it malleable or a potter heat his kiln to transform clay into pottery. Or you will have seen your toaster elements operating red hot.

You can simulate the colour emitted by a heated object and thus estimate its operating temperature by using a 12V 50W halogen lamp and varying the applied voltage to it. With normal vision, the eye can quite reliably compare the lamp colour with the heated object and hence determine the temperature.

The tungsten filament has a temperature coefficient of resistance of .0045 per degree Celsius. It's resistance is:

$R = R_{20°C} \times (1 + .0045\Delta T)$

Note that $.0045\Delta T$ is 1 for every 225°C rise in temperature – ie, the filament resistance doubles from that at 20°C for a rise in temperature of 225°C, trebles for a rise of 450°C and so on. At the operating temperature of a halogen lamp, the filament approaches 3000°C and the resistance is more than 14 times its cold value.

Using a laboratory DC power supply and calculating the resist-

continued next page . . .

Timer for MIG welder

Up-market MIG welders have a feature to start the gas shielding a moment before the wire feed and the welding current is applied. This provides the ideal protection for the base material and the consumable welding wire. This 2-stage timer provides a similar facility on cheaper MIG welders.

It uses two 555 timers (IC1 & IC2) and three relays. When the trigger on the welding gun is operated, it pulls pin 2 of IC1 and one side of relay RLY1 low. This initialises IC1 and its output at pin immediately goes high.

Relay RLY1 starts the gas flowing and after a short delay, IC1's output goes low and triggers timer IC2 which immediately energises relays RLY2 & RLY3.

IC2's time delay is very short so that there is no noticeable delay in switching off the wire feed or the welding current when the trigger is released. Relay RLY2 provides the latching function that keeps relays RLY2 & RLY3 energised while ever the trigger on the welding gun is held closed.

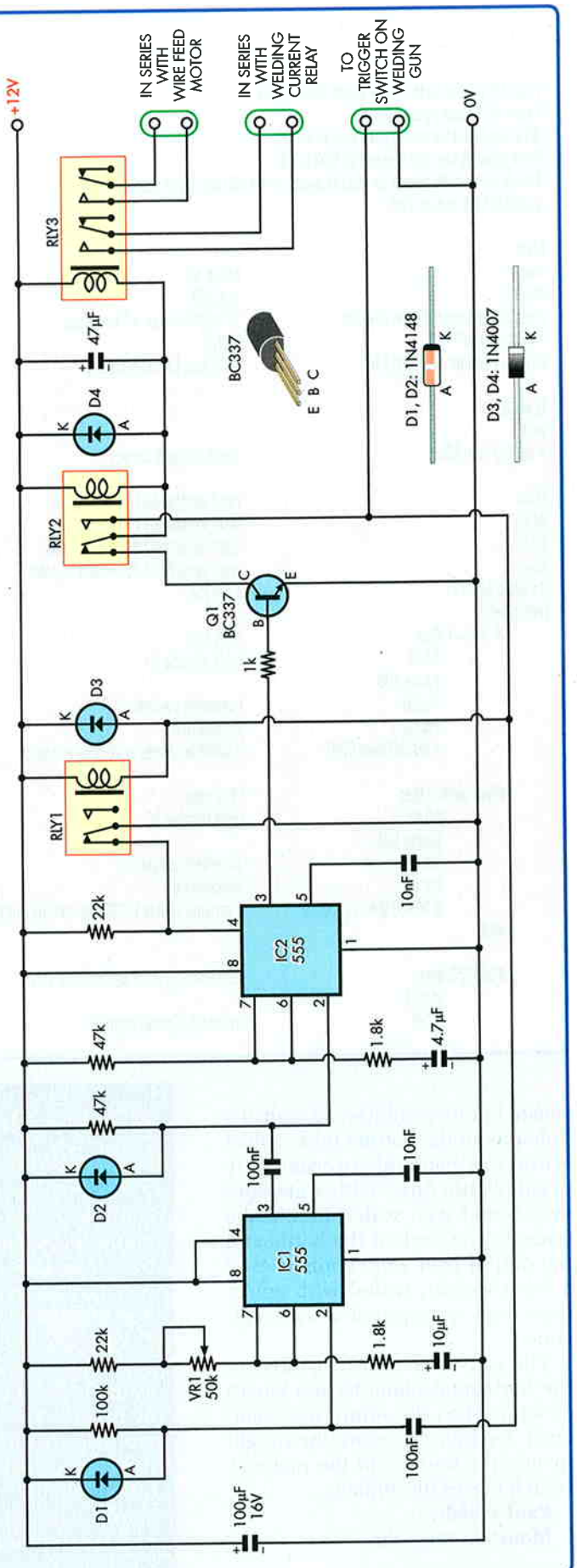
Relay RLY3 provides switching of the wire feed motor and the welding current relay.

The normally closed contact in relay RLY1 which connects pin 4 of IC2 to the negative rail is there to keep IC2 in the reset state during the initial switch-on of the welder power. When relay RLY1 is energised, this releases the reset state and pin 4 of IC2 is pulled high via a 22kΩ resistor. The 47µF capacitor across the coils of relay RLY2 & RLY3 is there to give a small hold-on time to allow the relays to latch.

Power to the device is provided by a 12V DC switchmode plugpack connected into a plug base wired into the welder's normal switched power source. It should be noted that no connections are made to the welders original electronics which control the wire feed rate or the welding current. The circuit was constructed on a PC board and is isolated from the welder's electrics, other than via the connections described above and these are only via the relay contacts.

The relays should have contacts rated 240VAC 10A, such as Jaycar Cat. SY-4052.

Cliff Wylie,
Leumeah, NSW. ($35)



Optical pyrometer continued . . .

ance for each change of voltage, you can verify that the rate of change of temperature follows a reasonably linear curve of 280°C/V between 1V (700°C) and 6V (2100°C), tapering off to about 150°C/V between 6V (2100°C) and 12V (3000°C). By using an accurate digital multimeter and adjusting the voltage to provide identical brilliance to the heated object, you can determine the temperature to (say) within ±50°C.

Victor Erdstein, Highett, Vic. ($45)

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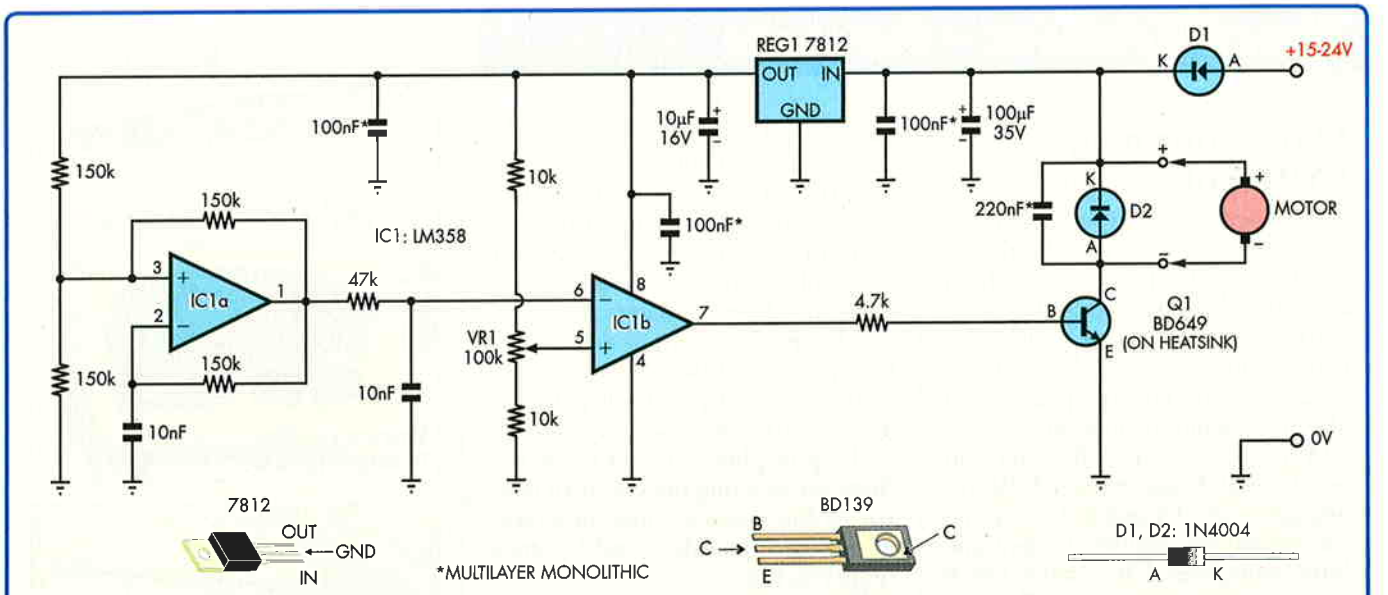

Simple DC motor speed control

This circuit uses a LM358 dual op amp and a BD649 Darlington power transistor to provide switchmode power control to a 12V or 24V DC motor.

IC1a is configured as a Schmitt trigger oscillator. Positive feedback is provided by the 150kΩ resistor from pin 1 to pin 3, while the 150kΩ resistor and 10nF capacitor on pin 2 set the operating frequency to around 400Hz. This produces a square-wave output at pin 1 of IC1 and this is fed to a low-pass filter consisting of a 47kΩ resistor and another 10nF capacitor.

The resulting triangle waveform is fed to the non-inverting input (pin 6) of IC1b and compared with the reference voltage (on pin 5) from the wiper of potentiometer VR1 (100kΩ). If VR1 is set for a low reference level, the result will be a 400Hz pulse train with a high duty cycle; ie, positive most of the time. This drives transistor Q1 to provide a high motor speed.

Similarly, if the reference level is set high, the resulting pulse train will have a low duty cycle and the motor speed will be low. Q1 can handle up to 5A provided it is fitted with an adequate heatsink.

Michael Azzopardi,
Deer Park, Vic. ($30)

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Make your own SMD tools

If you work with surface-mounted devices (SMD) then you'll appreciate the need for tools to aid in the handling and measurement of these truly miniature devices. While special apparatus are available for these tasks, they are typically priced well above the hobbyist market.

A variety of special tools can be made at home with a little ingenuity – as demonstrated by the accompanying photos. These basic tools were found to enable much easier measurement and PC board placement.

The first tool is based on a cheap pair of tweezers bought from an electronics outlet or any chemist. Tiny gold-flash contacts cut from an old computer AT bus card (eg, a VGA or sound card) edge connector are then glued to the internal faces of the tweezers.

These contacts are usually situated on both sides of the card's edge connector but are too thick to glue directly onto the tweezers. To overcome this problem, cut one set of double-sided contacts off the card with a small hacksaw blade. Take great care not to damage the gold plating during this operation. Overall size should be 8mm long by about 2.5-3mm wide (slightly larger than the tweezers tip) with the gold "finger" situated in the middle.

It should then be easy to split the piece of PC board into two sections using a razor blade or craft knife, such that each section has a gold-plated surface. As the piece is very small it should come apart with minimal pressure applied to the blade. Most circuit boards are made up of many layers of material glued together; this allows the contacts to be made as thin as needed, simply by splitting off more layers with the razor blade. Some board material is needed to form an insulator between the gold contact and the tweezer tips, so don't trim off too much.

Scuff the tips of the tweezers with sand paper and glue the prepared contacts to the tips with some good quality superglue. Naturally, you should not get any glue on the gold-plated surface! After the glue has completely hardened (up to 24 hours), file each contact neatly to the shape of the tips of the tweezers.

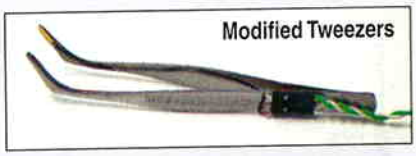
Next, solder some very fine insulated wire to the upper edge of the contacts. You'll need to use a small soldering iron tip and fine solder to avoid contaminating the majority of the gold-plated surface. Now run these wires along the inside of each leg of the tweezers and tack glue at regular intervals to hold permanently in place.

Finally, terminate the wire at a small 2-pin connector at the end of the tweezers. The author used wire-wrap wire but any small gauge wire (perhaps from a mouse cable, for example) would be suitable. Use a length of flexible, heavier gauge wire to go from this connector to your test gear.

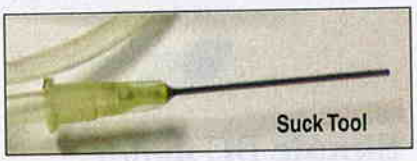
The tweezers tool will have some inherent capacitance, as will your hand – both of which must be accounted for when measuring small capacitor values. If you are using a Peak LCR meter, you can zero out this unwanted capacitance by squeezing the tweezers together while holding the test button down for more than five seconds. In fact, the Peak LCR meter is an ideal companion to the tweezers, allowing a large number of components to be categorised and tested in short order, thanks to its automatic resistor/capacitor/inductor discrimination.

The second tool allows accurate "pick and place" of many small SMD components, duplicating the function of expensive machines. As shown in the photo, it is simply a hypodermic syringe needle without the plastic body. The author used a 0.9mm x 38mm "Terumo" brand needle.

The sharp end is ground "square" and cleaned up with fine emery paper to get a good seal, as we'll see in a moment. Force a fine strand of wire into the tip to clean out the hole from the inside. A 600mm length of small-bore clear plastic hose (3mm ID & 4mm OD) can then be fitted over the other end of the needle. This is normally used for fuel lines on weed trimmer motors and can be bought from hardware stores.


Modified Tweezers

Measure 0402 Size Resistors With Ease


Suck Tool

Picking Up SMDs With The Suck Tool

In use, the tip of the needle is placed against the body of the SMD component to be moved and a small vacuum is applied to the free end of the tube. To do this, you simply suck gently on the tube! The negative pressure created is enough to pick up the smallest 0402 size SMD capacitors, resistors and transistors, right through to some of the larger 20-pin IC devices. It will not pick up MELF devices – only those with flat tops!

The tubed end of the needle has a plastic collar, making it easy to hold and manipulate component position. Once in place, the component is released by slightly reducing the vacuum. If the device is to be soldered, it can then be held in place by applying light downward pressure with the needle while tacking it to the board using your free hand.

Ron Russo,
Kirwan, Qld. ($80)

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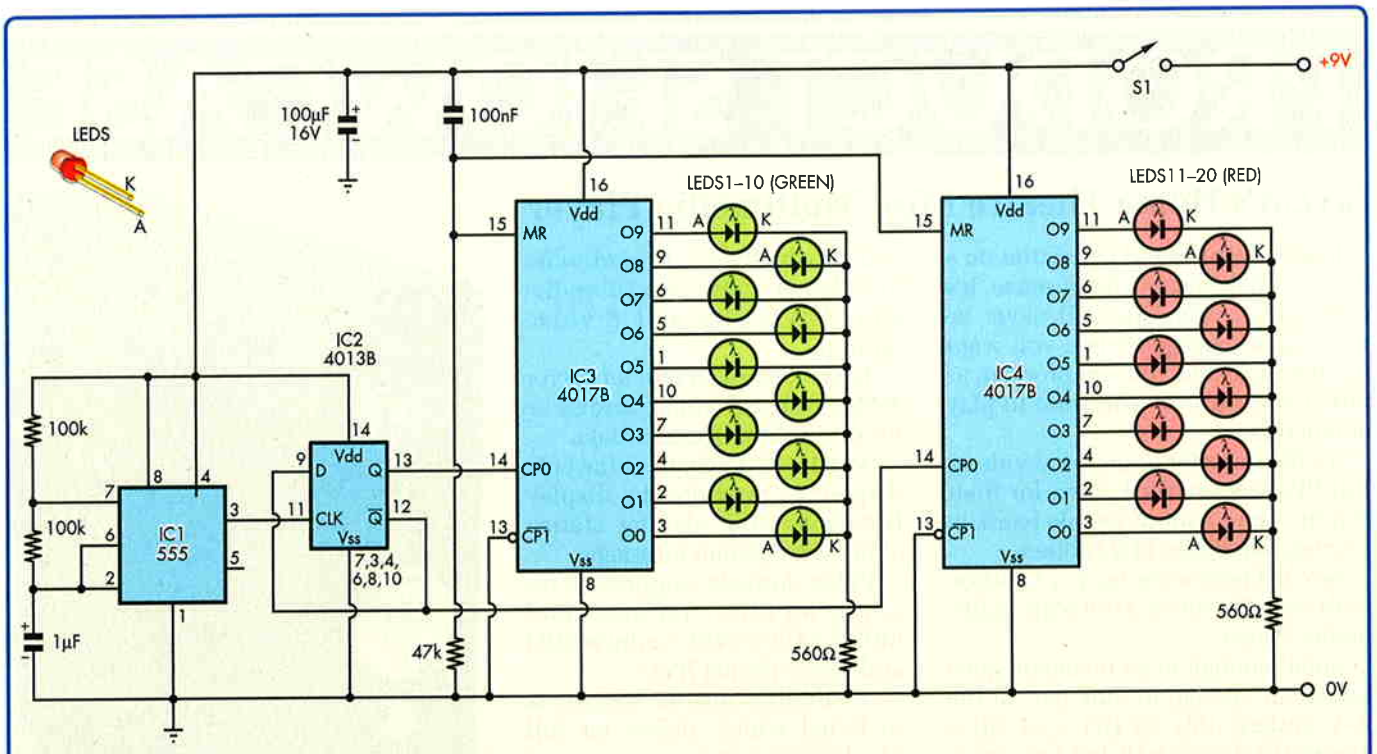

Leap-frogging LED chaser

This is a 20-LED chaser with alternate red and green LEDs. When run at a modest speed it looks as though a green LED jumps over a red LED, a red over green and so on, giving an eye-catching display.

Two 4017 decade counters (IC3 & IC4) drive the LEDs. A 555 timer (IC1), wired as an astable multivibrator, provides the clock pulses and these are fed to one section of a 4013 dual D flipflop (IC2).

The alternating outputs of the flipflop are fed to the clock inputs of the two 4017s; it is the alternate clocking of the 4017s which causes the apparent leap-frogging effect. As well, the LED outputs from the two 4017 counters must be interlaced.

A. J. Lowe,
Bardon, Qld. ($35)

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As you can see, we pay good money for each of the "Circuit Notebook" items published in SILICON CHIP. But there are four more reasons to send in your circuit idea.

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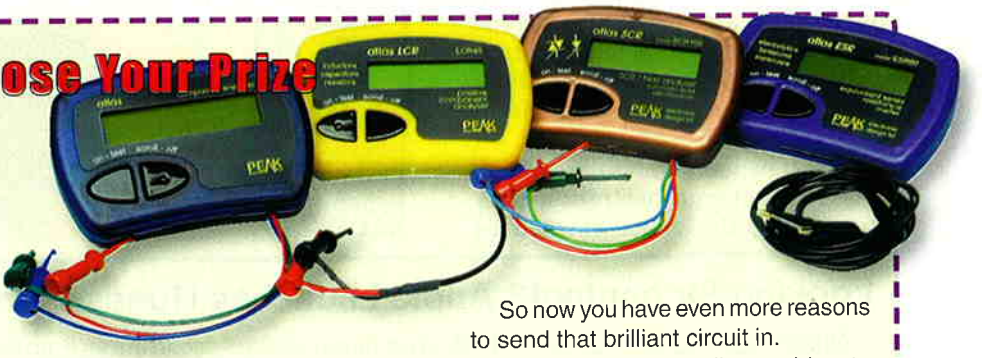

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PRODUCT SHOWCASE

Jaycar's Home Theatre Mini Multimedia Player

Placing your music collection on a PC hard disk makes a lot of sense. It's convenient, your CDs will never be missing or damaged when you want to play them and you can program as much or as little as you want to play at one time.

It's the same for photos and videos. But PCs were never known for their beauty – and a lot of people baulk at placing one in the hi fi cabinet.

Jaycar Electronics have a solution with their XC-4866, $199 (rrp) Multimedia Player.

Small enough to be inconspicuous but smart enough to look part of the A-V system, this 45 (w) x 21 (d) x 18mm (h) device will hold as much of your audio and video as you want it to – because you supply the hard disk drive that goes inside it (up to 500GB).

The idea is simple enough: fit the hard disk drive of your choice, connect the player to your PC via a mini USB cable (supplied) and copy what you want onto the disk.

Then you can disconnect it from your PC and use it as a stand-alone player, complete with remote control. It also has the now-familiar iPod-type 4-way jog controller on the front panel.

The rear panel contains the connections for your home theatre system or hifi – you get the choice of standard yellow/white/red video and audio via RCA sockets, coaxial audio; and YUV/CVBS and S-video outputs.

There's also a slot for an SD (or MMC/MS) card which can also be used to hold or transfer data.

An 84 x 84 dot matrix blue LCD display is provided to display filenames and playing status, along with system messages.

Video formats supported include MPEG-1, MPEG-2 and MPEG-4 Divx Xvid. Audio is MP3 and image format JPEG.

A slimline remote control is included which allows for full playback functions, zoom and slideshow control. Supplied cables include a 3-way RCA and mini USB, along with the 240V

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Jaycar Electronics (all stores)
100 Silverwater Rd Silverwater 2128
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Website: www.jaycar.com.au

Looking for content? Apple Launches iTunes Plus: 256kbps AAC encoding

Apple's new iTunes Plus offers DRM-free music tracks featuring high quality 256kbps AAC encoding with audio quality virtually indistinguishable from the original recordings – for $2.19 (RRP inc GST) per song.

iTunes Plus is launching with EMI's digital catalog of outstanding recordings

iTunes will continue to offer its entire catalog, currently over four million songs, in the same versions as today—128kbps AAC encoding with DRM—at the same price of $1.69 including GST per song, alongside the higher quality iTunes Plus versions when available.

In addition, iTunes customers can now easily upgrade their library of previously purchased EMI content to iTunes Plus tracks for just 50c a song and $5.10 for most albums.

With the release of iTunes Plus, customers can now download tracks from their favourite EMI artists without limitations on the type of music player or number of computers that purchased songs can be played on. iTunes is also offering customers a simple, one-click option to easily upgrade their library of previously purchased EMI content to the iTunes Plus versions. EMI music videos are now also available in iTunes Plus versions with no change in price. iTunes Plus songs purchased from the iTunes Store will play on all iPods, Mac or Windows computers, widescreen TVs with Apple TV, as well as many other digital music players.

The iTunes Store, which has sold over 2.5 billion songs making it the world's most popular online music store, features the world's largest catalog with over four million songs, 7000 music videos, 100,000 podcasts and 23,000 audiobooks.

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Programmable Power Supply

The new Motech PPS 3210 programmable power supply is a high resolution (16-bit) system with three channels providing 0-30VDC (channels 1 and 2, with 90W rating) and 0-15VDC (channel 3) with a 30W rating, suitable for testing computer and other IT equipment. Voltage programming speed is unimpeded by rise time limitations, with a 1ms response at full load and a fall time of 2.5ms. An internal time-recorder can provide off-time adjustable over a wide range (1s to 100h) to accommodate various burn-in and accelerated life-time testing.

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Website: www.westek.com.au

Microzed has new GPS-to-Microcontroller chip

Micromega Corporation, represented in Australia by Microzed Computers, announces the release of the uM-FPU V3.1 Floating Point Coprocessor chip. The new chip extends the powerful feature set of the original uM-FPU V3 chip to include serial I/O support, NMEA sentence parsing, block transfers, additional matrix operations and string support, and many other enhancements.

The new serial I/O capabilities with NMEA sentence parsing makes it easy to add GPS data to embedded system designs. GPS data can be read and processed directly by the uM-FPU V3.1 chip, saving I/O pins, memory space and execution time on the microcontroller, which can then be used for the main application.

As an added benefit, GPS data is immediately available on the uM-FPU V3.1 chip for further navigational calculations using the powerful floating point instruction set. The uM-FPU V3.1 chip interfaces to virtually any microcontroller using an SPI interface or I^2C interface, making it ideal for microcontroller applications requiring floating point math, including GPS, sensor readings, robotic control, data transformations and other embedded control applications.

Contact:
Microzed Computers Pty Ltd
PO Box 5103, Chittaway Bay NSW 2261
Tel: 1300 735 420 **Fax:** 1300 735 421
Website: www.microzed.com.au

USB to PCMCIA Adapter for 3G Internet Cards

This USB adapter from Microgram allows the use of a wide number of high speed datacards via a USB port, enabling these PC cards to be used with a desktop or laptop without a CardBus slot. Now you can take your 3G wireless internet access anywhere!

It is ideal for those who live in an area without high speed wired internet access, or whose laptop does not offer a PC/CardBus slot (most new laptops have ExpressCard slots). The adapter is compatible with desktops, notebooks or specialist systems (such as Point-of-Sale machines).

Most CardBus wireless modem cards are compatible. Check the list below to find out if yours is included or contact Microgram.

Known Compatible Cards:
Huawei E618 CDMA (Vodafone)
Maxcard "Maxcard+" CDMA (Telstra)
Globetrotter 3G and Fusion cards (One, Optus)
Sierra Wireless Aircard 580 CDMA (Telstra)
EVDO CDMA MM-5500C

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All kits are priced well under the normal recommended retail price, leaving enough of the TFYT allowance (where applicable) to spend on power tools. Each kit also includes a bonus 400mm Irwin Builder's Bag, which would normally retail for $50.

Irwin Apprentice Kits are available through all good tool specialists and selected hardware retailers. A brochure is available from Irwin Industrial Tools.

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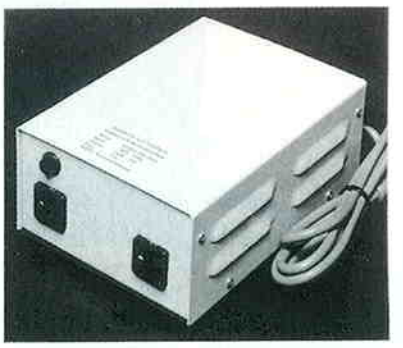

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Vintage Radio

By RODNEY CHAMPNESS, VK3UG

The Weston Model 660 Radio Set Analyser

Ever since the advent of radio communications at the start of the 20th century there has always been a need for test instruments. This month, we take a look at some of the common test instruments that were used and describe the unusual Weston Radio Set Analyser Model 660.

MANY DIFFERENT TEST instrument have been used in the radio field over the years. Some are quite complicated but sometimes they can be extremely simple – even just a finger or a screwdriver!

For example, with octal and pre-octal valves, it was common for the control grid to come out to a cap on the top of the valve. As a result, it was common for a serviceman to touch the grid cap of valves like the 6B6G to see if there was a healthy "blurt" from" the loudspeaker due to the resulting injected hum.

This test method was quite effective in determining that the audio amplifier was actually working. However, it gave no real indication as to how well the stage was operating.

There was also a trap here for the unwary. Not all valves have their top cap (if one exists) connected to the control grid. For example, some power valves like the 807 and the 6DQ6A/B have the plate (anode) attached to this terminal **and so the top cap operates at the potentially lethal HT voltage!**

For this reason, it is always necessary to check what is connected to the top cap before touching it, as death is permanent! And even if the top cap doesn't normally operate at high voltage, it's possible that a lethal voltage can appear there under fault conditions.

In short, although servicemen used this technique for many years, it is not recommended because of the possibility of electrocution. At the very least, always use a multimeter to check whether a high voltage is present at the top cap.

The Weston Model 660 opened up and ready for action. The abbreviated instructions are on a label attached inside the lid.

The screwdriver technique

Now I'll tell you about the common screwdriver test technique. Most servicemen in early times could only afford an elementary 1000 Ohm per volt multimeter. Only a few had access to equipment such as signal generators, capacitor testers and valve testers, etc and those that did often built the gear themselves.

Some so-called "servicemen" didn't even use a multimeter and labelled those servicemen who did as "sissies". Instead, they were quite content to use a screwdriver as a test instrument.

In practice, the screwdriver was used to short out various sections of a set while listening for the effect in the speaker (or headphones) and – sometimes – observing the size of the spark. For example, momentarily shorting the HT (high-tension) line to chassis to determine if there was any high tension was a common test – if HT was present, there would be a sizeable spark!

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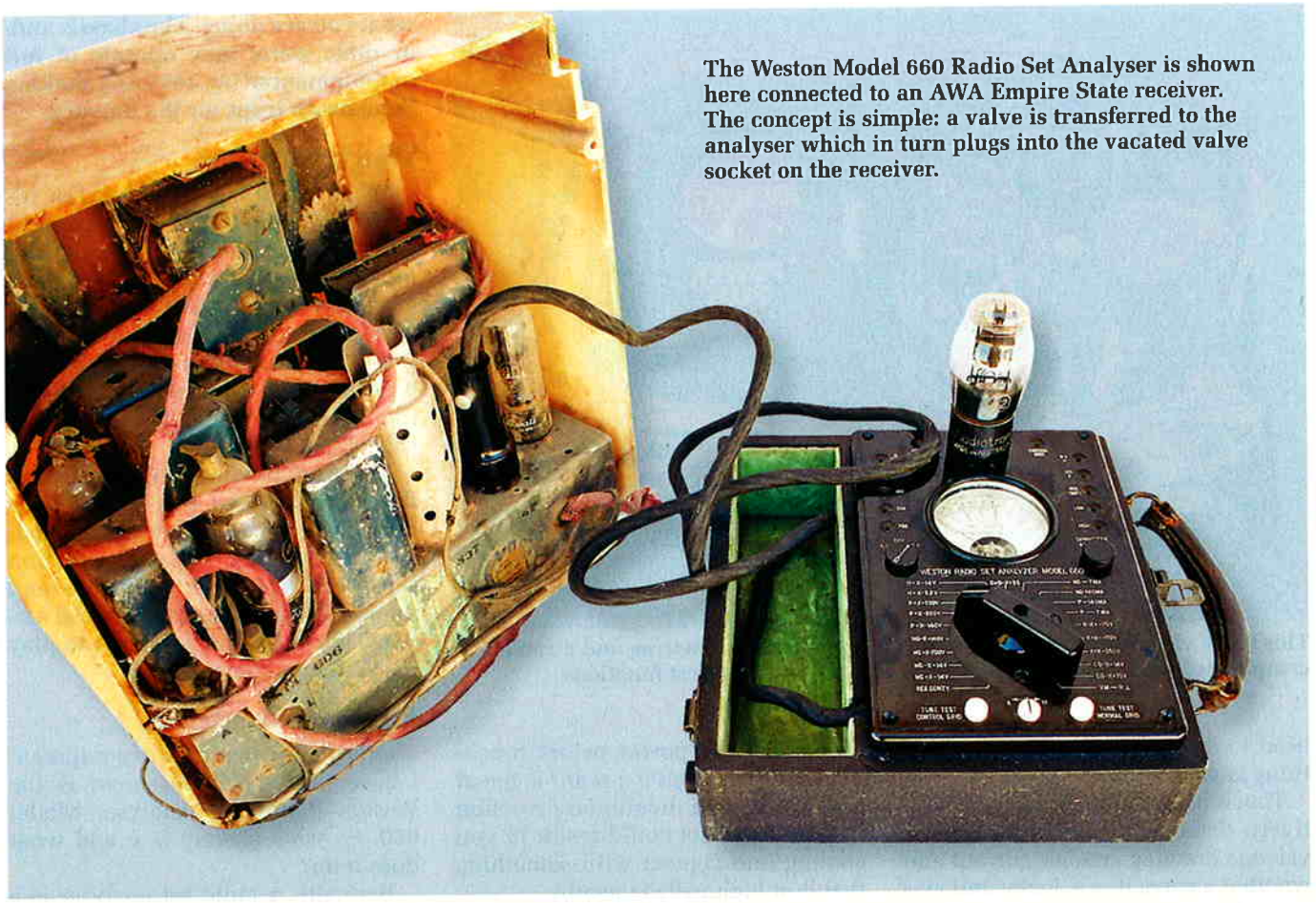


The Weston Model 660 Radio Set Analyser is shown here connected to an AWA Empire State receiver. The concept is simple: a valve is transferred to the analyser which in turn plugs into the vacated valve socket on the receiver.

Of course, rectifiers, chokes, filter capacitors and transformers do not take kindly to that sort of treatment. And just try this with solid state circuitry and see how long the transistors and other solid-state devices last!

Many so-called servicemen were very proud of the fact that a screwdriver was all they used to trace faults in early days. However, all they could really determine was that amplification was taking place in a certain stage or that a voltage was at a particular point. They had no idea if the gain of the set was normal or if the voltages were as they should be.

Although this technique (practised with extreme care) could be useful in some circumstances, I certainly do not recommend it. **It is potentially very dangerous and there are much safer techniques available, both for the set itself and the serviceman.**

Something more dangerous!

As if the screwdriver test technique wasn't bad enough, there was another even more dangerous test technique that was used by a few (mainly) deceased "servicemen". What they did was to use their fingers to "test" the voltages in a receiver, the claim being that they could judge the voltage levels by the shocks they received. Just how many died trying this insane "test" method is unknown.

Fortunately, this stupid and potentially lethal technique died out many years ago – pun intended.

Observation

There are of course other fundamental "test" instruments that we all have. The most important are our senses of sight and smell.

When you have a set to restore, the first step after removing it from its cabinet is to use your nose to check for burnt smells from power transformers and resistors, or any other parts that may have seriously overheated. It's then a matter of using your eyes to see where the obnoxious smells are coming from.

This may take quite a bit of doing in some cases and a multimeter will be useful when it comes to checking any suspect parts for shorts.

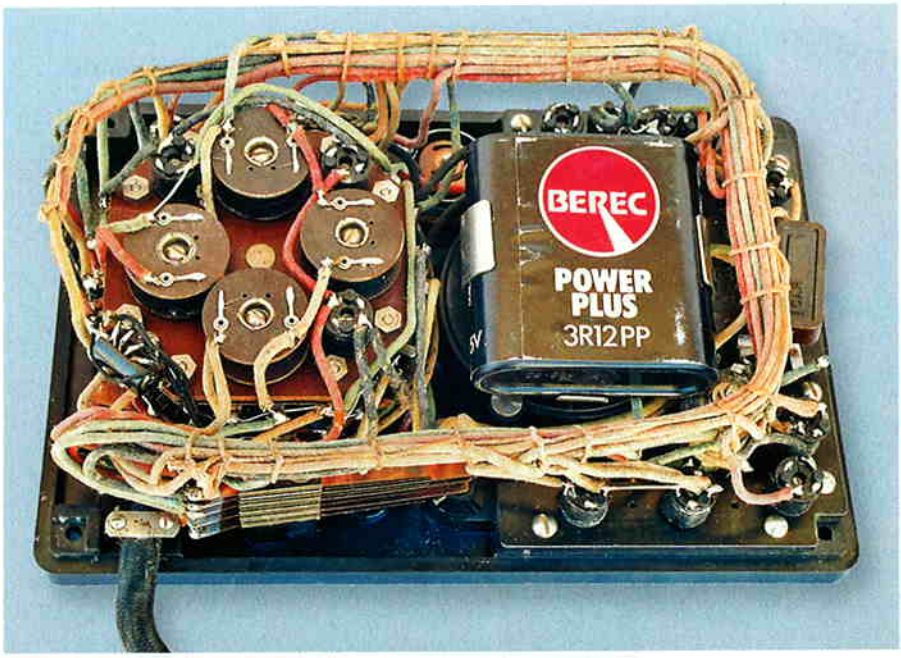
At the same time, use your eyes to check for wiring changes that shouldn't be there, including components with only one lead connected to anything. Badly soldered joints can sometimes be picked up in this way too, particularly if a head-set magnifier is used.

Cracked or melted insulation can also easily be spotted, as can corrosion in parts such as the aluminium vanes of tuning capacitors.

Your senses of sight and smell are also important when power is subsequently applied to the set. These will sometimes allow you to detect any problems that were not detected when the set was un-powered.

Your sense of hearing is important too when it comes to judging the signal quality. It's also useful for tracking down problems such as hissing, crackling and other noises from a faulty receiver.

Your sense of touch is another useful tool. This can be used to assess whether something is getting hotter than it should or, in some cases, isn't getting hot enough. Similarly, it can be



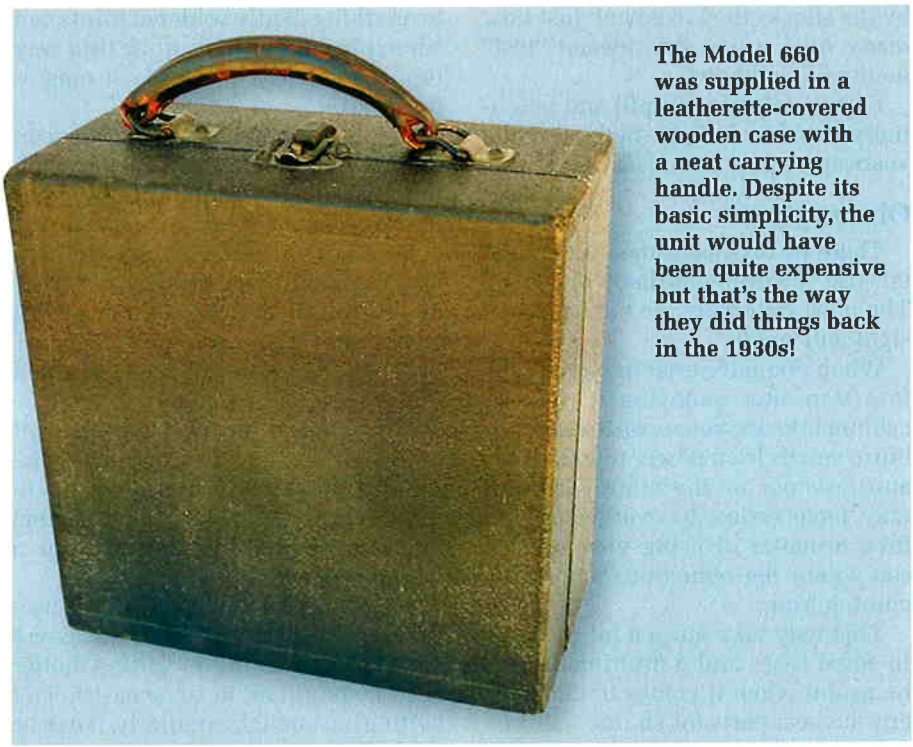
This is the view inside the Model 660. It employed lots of wiring and a rather complicated switching arrangement to select the various test functions.

used to detect whether or not something is vibrating.

Touch can also be used to subjectively determine whether a power valve is drawing enough current and whether a capacitor is leaky and as a result is heating up.

Of course, a great deal of care is needed here to ensure that you don't touch a high-voltage circuit or burn your finger. The safe method is to disconnect the power before touching anything. Even if a point is not at high voltage, an involuntary reaction to something hot could result in you coming into contact with something that is at high voltage nearby.

It's also vital that you understand the type of circuit you're working on here. **Never go poking around transformerless AC/DC sets unless you are very experienced and know exactly what you are doing. The chassis and/or other parts may operate at full mains potential (ie, 240VAC), making them death traps for the unwary.**



The Model 660 was supplied in a leatherette-covered wooden case with a neat carrying handle. Despite its basic simplicity, the unit would have been quite expensive but that's the way they did things back in the 1930s!

Watch your eyes

When servicing an old radio, it's always advisable to wear protective glasses in case something spits out molten metal or explodes – eg, an electrolytic capacitor. Be warned also that some faulty components can give off obnoxious fumes which are best avoided – especially carcinogens like the PCBs found in some block capacitors.

Take care of your hearing also and don't subject your ears to excessive noise levels – eg, when wearing headphones. In short, use your common sense and avoid the dangerous and foolhardy test methods described earlier. They have no useful role to play in servicing vintage radios.

Radio Set Analyser

One interesting piece of equipment I have recently come across is the Weston Radio Set Analyser Model 660. So what exactly is it and what does it do?

Basically, a radio set analyser is a device that's used to check the operating conditions of a valve in a radio circuit. In the early days of radio, during the breadboard construction days, all terminals and leads were accessible from the top of the set. But then – shock, horror – the metal chassis was introduced, with components mounted on both sides. Throw in the additional complexity of tetrode and pentode valves, along with the mysterious new superheterodyne receiver circuit, and many radio enthusiasts simply gave up.

The analyser did, however, make things somewhat easier for those traumatised radio enthusiasts brought up on breadboard construction and coffin-style cabinets. That's because it allowed most testing to be done from the top of the chassis, which made troubleshooting more straightforward.

The stage to be tested first had its valve removed. The lead from the analyser was then plugged into the vacated valve socket, either directly or via a suitable adaptor. That done, the valve was then plugged into the analyser, the set powered up and the valve's performance assessed.

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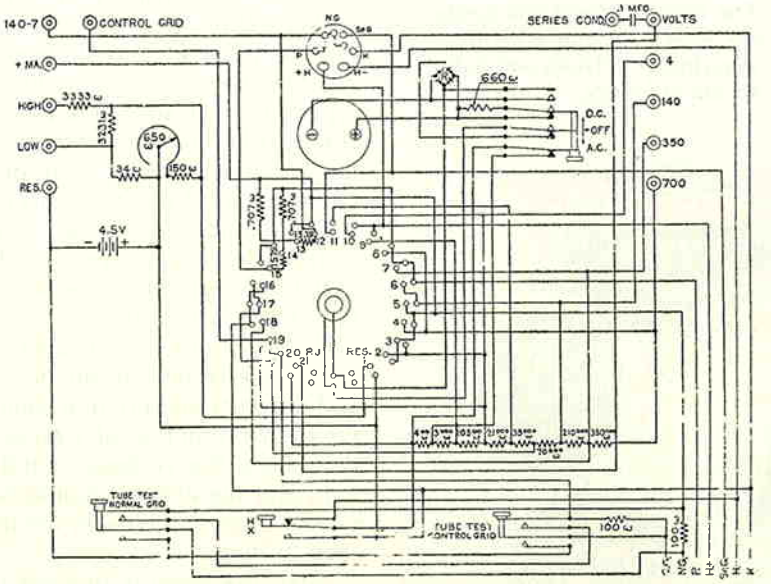

Weston Electrical Instrument Corp.
NEWARK, N. J.

Fig.1: the circuit of the Weston Model 660 Radio Set Analyser is basically a combined multimeter, elementary valve tester and set analyser.

In practice, its current could be measured, along with the voltages applied to its various elements. It was even possible to gauge the gain of the valve using various tests and to measure resistances.

In short, the analyser was designed to largely solve the perceived problem of removing the receiver chassis from the cabinet for servicing. Valves weren't particularly reliable in those days, so the analyser solved the problem of checking the most vulnerable parts of the radio (ie, the valves) with ease.

As far as I can discover, the radio set analyser was developed in the United States during the late 1920s and early 1930s. In fact, quite a bit was written about these analysers in "Modern Radio Servicing" by Alfred Ghirardi in 1935.

By contrast, only a two-paragraph mention is made of radio set analysers in the Philips Radio and Television Manual by E. G. Beard following World War 2. The reason for this is probably that when octal valves were introduced, the limitations of the analyser were too great to warrant further development.

Weston Model 660

The Model 660 is probably an early 1930s instrument, as Ghirardi's book shows a 666 which appears to be a later version. As mentioned earlier, the average radio servicemen in Australia could only afford a multimeter to overhaul a faulty receiver. The 660, along with the analysers made by other manufacturers, would have been expensive instruments in their time, so not many were sold in Australia.

In its time, the 660 would have been viewed with a certain amount of awe. It is housed in a 225 x 230 x 115mm leatherette-covered wooden case with a neat carrying handle. The case opens up to present the instrument which is finished in the characteristic black colour of the era.

Basically, the unit is a combined multimeter, elementary valve tester and set analyser. On the lower section of the front panel is a large multi-function switch with 21 marked positions. Above this is a 65mm meter marked with the various ranges, while to either side of this are several sockets to use with the analyser in the multimeter mode.

The valve socket is located directly above the meter. This accepts the valves that are removed from the receiver being tested, either directly or via a plug/socket adaptor.

The connection to the empty valve socket on the receiver is made via a 1.3-metre long cable which emerges from

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The Weston Model 660 Radio Set Analyser came with an assortment of leads and valve socket adapters.

the lefthand side of the instrument. This cable is fitted with a 6-pin valve plug, with both large and small grid caps on the upper part of the plug.

On the inside cover of the instrument is a set of abbreviated operating instructions, along with a circuit diagram. However, these are not all that clear and the handbook that goes with the instrument had long since disappeared.

Using the unit

The unit is used as follows: with the radio turned off, a valve in the set is removed and the set analyser "wander" plug inserted into the empty valve socket – if necessary, via an adaptor. The use of an adaptor all depends on whether the valve is a four, five, six or 7-pin type. If an adapter is used, then a similar adaptor may also be needed at the instrument end, so that the valve can be plugged into the analyser.

The adaptors, by the way, are colour coded either blue or orange and made so that the correct adaptor can only be used in each location.

Once the unit is connected, the set can then be turned on and the voltages and currents measured at each valve pin (ie, without the valve present). At this stage, the voltages should read high and the current should be zero unless there is a bleeder circuit or a fault in the set.

Next, the valve is plugged in and the above tests repeated. The heater or filament voltages should remain virtually the same but the voltages on the plates and screens should be somewhat lower, depending on the circuit. The current drawn by the valve for its screen and plate circuits should be within the range expected for the particular valve type and the circuit configuration.

Switching between ranges on the model 660 while the receiver is operating doesn't cause problems as the range switch is a "break before make" type. Conversely, switching between measurements on the different valve elements should be done with the AC-OFF-DC switch in the "off" position, otherwise the meter may be damaged.

Interpreting the results

Having done these tests, it was then up to the operator to interpret the results. This was generally based on experience, although some manufacturers even provided the expected voltage and current readings for their sets so that set analysers could easily be used.

Having tested the set in a static condition, it was then possible to see if the valve appeared to be amplifying. This was done by pressing either (or both) the "Tube Test Control Grid" or the "Tube Test Normal Grid" switch, which applied an offset voltage to the grid. A variation in the current drawn by the valve would then be observed if the valve was operating correctly.

Each valve circuit in the set would be tested in sequence until the faulty

Rotary Switches: Making The Break

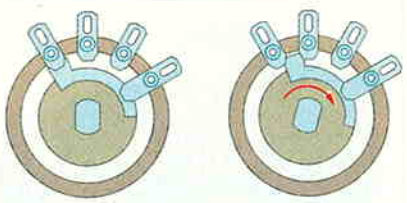

Fig.2: a "make-before-break" switch at rest and in transistion.

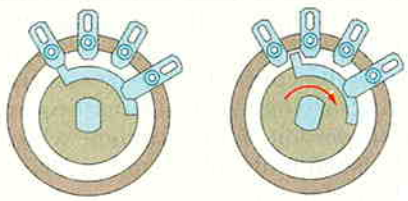

Fig.3: a "break-before-make" switch uses a narrower moving switch contact.

There are two different types of rotary switches used in vintage radios – "make before break" and "break before make". The differences between them are critical in many situations, as we shall see.

Most rotary switches are "make before break" units. This means that as you switch ranges, the adjoining switch sections are connected together ("commoned") for an instant – see Fig.2. This is not important for applications like wave-change switches but can be disastrous in other situations such as when different voltages are to be switched. In the latter case, using a make before break switch could easily lead to its contacts being burnt out and/or the equipment damaged.

The commonly used "Oak" switches are mostly "make-before-break" types but Oak also manufactured "break-before-make" switches. In this type, the moving part of the switch contact is much narrower than in the "make-before-break" units, in order to achieve the break during switching – see Fig.3

Both switch types are used in vintage radios and if you have to replace a switch, be sure to choose the correct type.

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stage was found – all without removing the set from its cabinet. The hope then was that the fault could be corrected simply by replacing the valve, as this was the most likely culprit. They were not as reliable in the 1930s as they were towards the end of the valve era.

Of course, this was really a rather elementary valve test and it wasn't always the valve that was at fault. If the tests were indeterminate in pinpointing the problem, it would then be necessary to remove the chassis and really get serious about servicing the set.

In reality, it's probable that the chassis had to be removed from its cabinet in at least 50% of the cases to cure any faults. Once the chassis had been removed from the cabinet, it could then be tested using the multimeter functions of the set analyser in much the same manner as with modern multimeters.

Why didn't they last?

The concept of being able to test most parts of a radio circuit without removing the chassis from the cabinet appealed to many people. So why were set analysers only used for a relatively short period of time.

First, although the idea of being able to remove a valve and plug in an analyser was attractive, the only easily replaced component was the valve itself. Replacing other components required access to the underside of the chassis, which nullified the supposed advantages of an analyser.

Now we come to the real problem of set analysers. In practice, a set's operating conditions were altered by extending the various valve element leads. In some receivers, neutralisation was required in the RF sections to overcome the effect of the grid to plate capacitance. This involved fitting a small capacitor.

However, with the leads extended, the grid and the plate leads are alongside each other and the neutralisation no longer works due to the altered operating conditions. In any set that used a tetrode or pentode valve in an RF stage, the fact that the grid and plate leads are now alongside each other would have completely nullified the shielding effect of the screen grid. As a result, the particular stage would probably oscillate uncontrollably.

Problems could also be expected when testing audio stages, The extended grid lead in the Weston Model 660 set analyser is unshielded, so excessive hum or even "squealing" (due to feedback) could be expected in the output of the audio amplifier if that stage was actually working.

In addition, interfering with the original chassis layout by extending the valve leads could result in incorrect voltage and current readings, simply because the circuit could now be behaving abnormally. An analyser may have worked quite well in checking circuits with low-gain valves. However, later valves had much higher gain than the early types and using an analyser with any circuit that used them would have been out of the question.

As a result, set analysers faded into obscurity within a relatively short period.

Summary

The Weston 660 Radio Set Analyser is an interesting test instrument from the early 1930s. It would have been quite expensive in its day but despite that, its usefulness would have been quite limited.

Rapidly evolving receiver design and servicing techniques very quickly rendered this type of instrument obsolescent and most would have soon been set aside to gather dust. Certainly, the example I have on loan indicates from its physical condition that it saw very little work. In practice, it would have been much easier for a competent serviceman to employ more conventional servicing techniques.

So if I'd been a serviceman in those early times, would I have bought one? Possibly, because when I was young, I liked to surround myself with test instruments to make up for my lack of knowledge. But knowing what I know now, the answer would have to be no. That said, this unit is well worth preserving as an example of a direction radio took for a short time. SC

Photo Gallery: Raycophone "Pee Wee"

PRODUCED BY THE RACOPHONE COMPANY, SYDNEY, in 1933, the "Pee Wee" was a small 4-valve autodyne superhet receiver. It was housed in an attractive wooden cabinet and used the following valve types: 57 autodyne mixer; 57 anode bend detector; 2A5 audio output; and 80 rectifier. Photo: Historical Radio Society of Australia, Inc.

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August 2001: DI Box For Musicians; 200W Mosfet Amplifier Module; Headlight Reminder; 40MHz 6-Digit Frequency Counter Module; A PC To Die For, Pt.3; Using Linux To Share An Internet Connection, Pt.3.

September 2001: Making MP3s; Build An MP3 Jukebox, Pt.1; PC-Controlled Mains Switch; Personal Noise Source For Tinnitus; Directional Microphone; Using Linux To Share An Internet Connection, Pt.4.

November 2001: Ultra-LD 100W/Channel Stereo Amplifier, Pt.1; Neon Tube Modulator For Cars; Audio/Video Distribution Amplifier; Build A Short Message Recorder Player; Useful Tips For Your PC.

December 2001: IR Transceiver For PCs; 100W/Ch Stereo Amplifier, Pt.2; Pardy Lights Colour Display; PIC Fun – Learning About Micros.

January 2002: Touch And/Or Remote-Controlled Light Dimmer, Pt.1; A Cheap 'n'Easy Motorbike Alarm; 100W /Channel Stereo Amplifier, Pt.3; Build A Raucous Alarm; FAQs On The MP3 Jukebox.

February 2002: 10-Channel IR Remote Control Receiver; 2.4GHz High-Power Audio-Video Link; Touch And/Or Remote-Controlled Light Dimmer, Pt.2; Booting A PC Without A Keyboard; 4-Way Event Timer.

March 2002: Mighty Midget Audio Amplifier Module; 6-Channel IR Remote Volume Control, Pt.1; RIAA Pre-Amplifier For Magnetic Cartridges; 12/24V Intelligent Solar Power Battery Charger.

April 2002: Automatic Single-Channel Light Dimmer; Pt.1; Water Level Indicator; Multiple-Output Bench Power Supply; Versatile Multi-Mode Timer; 6-Channel IR Remote Volume Control, Pt.2.

May 2002: 32-LED Knightrider; The Battery Guardian (Cuts Power When the Battery Voltage Drops); Stereo Headphone Amplifier; Automatic Single-Channel Light Dimmer; Pt.2; Stepper Motor Controller.

August 2002: Digital Instrumentation Software For PCs; Digital Storage Logic Probe; Digital Therm./Thermostat; Sound Card Interface For PC Test Instruments; Direct Conversion Receiver For Radio Amateurs.

September 2002: 12V Fluorescent Lamp Inverter; 8-Channel Infrared Remote Control; 50-Watt DC Electronic Load; Spyware – An Update.

October 2002: Speed Controller For Universal Motors; PC Parallel Port Wizard; Cable Tracer; AVR ISP Serial Programmer; 3D TV.

November 2002: SuperCharger For NiCd/NiMH Batteries, Pt.1; Windows-Based EPROM Programmer, Pt.1; 4-Digit Crystal-Controlled Timing Module; Using Linux To Share An Optus Cable Modem, Pt.1.

December 2002: Receiving TV From Satellites; Pt.1; The Micromitter Stereo FM Transmitter; Windows-Based EPROM Programmer, Pt.2; SuperCharger For NiCd/NiMH Batteries; Pt.2; Simple VHF FM/AM Radio; Using Linux To Share An Optus Cable Modem, Pt.2.

January 2003: Receiving TV From Satellites, Pt 2; SC480 50W RMS Amplifier Module, Pt.1; Gear Indicator For Cars; Active 3-Way Crossover For Speakers; Using Linux To Share An Optus Cable Modem, Pt.3.

February 2003: PortaPal PA System, Pt.1; SC480 50W RMS Amplifier Module, Pt.2; Windows-Based EPROM Programmer, Pt.3; Using Linux To Share An Optus Cable Modem, Pt.4; Fun With The PICAXE, Pt.1.

March 2003: LED Lighting For Your Car; Peltier-Effect Tinnie Cooler; PortaPal PA System, Pt.2; 12V SLA Battery Float Charger; Little Dynamite Subwoofer; Fun With The PICAXE, Pt.2 (Shop Door Minder).

April 2003: Video-Audio Booster For Home Theatre Systems; Telephone Dialler For Burglar Alarms; Three PIC Programmer Kits; PICAXE, Pt.3 (Heartbeat Simulator); Electric Shutter Release For Cameras.

May 2003: Widgybox Guitar Distortion Effects Unit; 10MHz Direct Digital Synthesis Generator; Big Blaster Subwoofer; Printer Port Simulator; PICAXE, Pt.4 (Motor Controller).

June 2003: PICAXE, Pt.5; PICAXE-Controlled Telephone Intercom; PICAXE-08 Port Expansion; Sunset Switch For Security & Garden Lighting; Digital Reaction Timer; Adjustable DC-DC Converter For Cars; Long-Range 4-Channel UHF Remote Control.

July 2003: Smart Card Reader & Programmer; Power-Up Auto Mains Switch; A "Smart" Slave Flash Trigger; Programmable Continuity Tester; PICAXE Pt.6 – Data Communications; Updating The PIC Programmer & Checkerboard; RFID Tags – How They Work.

August 2003: PC Infrared Remote Receiver (Play DVDs & MP3s On Your PC Via Remote Control); Digital Instrument Display For Cars, Pt.1; Home-Brew Weatherproof 2.4GHz WiFi Antennas; PICAXE Pt.7.

September 2003: Robot Wars; Krypton Bike Light; PIC Programmer; Current Clamp Meter Adapter For DMMs; PICAXE Pt.8 – A Data Logger; Digital Instrument Display For Cars, Pt.2.

October 2003: PC Board Design, Pt.1; JV80 Loudspeaker System; A Dirt Cheap, High-Current Power Supply; Low-Cost 50MHz Frequency Meter; Long-Range 16-Channel Remote Control System.

November 2003: PC Board Design, Pt.2; 12AX7 Valve Audio Preamplifier; Our Best Ever LED Torch; Smart Radio Modem For Microcontrollers; PICAXE Pt.9; Programmable PIC-Powered Timer.

December 2003: PC Board Design, Pt.3; VHF Receiver For Weather Satellites; Linear Supply For Luxeon 1W Star LEDs; 5V Meter Calibration Standard; PIC-Based Car Battery Monitor; PICAXE Pt.10.

January 2004: Studio 350W Power Amplifier Module, Pt.1; High-Efficiency Power Supply For 1W Star LEDs; Antenna & RF Preamp For Weather Satellites; Lapel Microphone Adaptor For PA Systems; PICAXE-18X 4-Channel Datalogger, Pt.1; 2.4GHZ Audio/Video Link.

February 2004: PC Board Design, Pt.1; Supply Rail Monitor For PCs; Studio 350W Power Amplifier Module, Pt.2; Shorted Turns Tester For Line Output Transformers; PICAXE-18X 4-Channel Datalogger, Pt.2.

March 2004: PC Board Design, Pt.2; Build The QuickBrake For Increased Driving Safety; 3V-9V (or more) DC-DC Converter; ESR Meter Mk.2, Pt.1; PICAXE-18X 4-Channel Datalogger, Pt.3.

April 2004: PC Board Design, Pt.3; Loudspeaker Level Meter For Home Theatre Systems; Dog Silencer; Mixture Display For Cars; ESR Meter Mk.2, Pt.2; PC/PICAXE Interface For UHF Remote Control.

May 2004: Amplifier Testing Without High-Tech Gear; Component Video To RGB Converter; Starpower Switching Supply For Luxeon Star LEDs; Wireless Parallel Port; Poor Man's Metal Locator.

June 2004: Dr Video Mk 2 Video Stabiliser; Build An RFID Security Module; Fridge-Door Alarm; Courtesy Light Delay For Cars; Automating PC Power-Up; Upgraded Software For The EPROM Programmer.

July 2004: Silencing A Noisy PC; Versatile Battery Protector; Appliance Energy Meter, Pt.1; A Poor Man's Q Meter; Regulated High-Voltage Supply For Valve Amplifiers; Remote Control For A Model Train Layout.

August 2004: Video Formats: Why Bother?; VAF's New DC-X Generation IV Loudspeakers; Video Enhancer & Y/C Separator; Balanced Microphone Preamp; Appliance Energy Meter, Pt.2; 3-State Logic Probe.

September 2004: Voice Over IP (VoIP) For Beginners; WiFry – Cooking Up 2.4GHz Antennas; Bed Wetting Alert; Build a Programmable Robot; Another CFL Inverter.

October 2004: The Humble "Trannie" Turns 50; SMS Controller, Pt.1; RGB To Component Video Converter; USB Power Injector; Remote Controller For Garage Doors & Gates.

November 2004: 42V Car Electrical Systems; USB-Controlled Power Switch (Errata Dec. 2004); Charger For Deep-Cycle 12V Batteries, Pt.1; Driveway Sentry; SMS Controller, Pt.2; PICAXE IR Remote Control.

December 2004: Build A Windmill Generator, Pt.1; 20W Amplifier Module; Charger For Deep-Cycle 12V Batteries, Pt.2; Solar-Powered Wireless Weather Station; Bidirectional Motor Speed Controller.

January 2005: Windmill Generator, Pt.2; Build A V8 Doorbell; IR Remote Control Checker; 4-Minute Shower Timer; The Prawnlite; Sinom Says Game; VAF DC-7 Generation 4 Kit Speakers.

February 2005: Windmill Generator, Pt.3; USB-Controlled Electrocardiograph; TwinTen Stereo Amplifier; Inductance & Q-Factor Meter, Pt.1; A Yagi Antenna For UHF CB; $2 Battery Charger.

March 2005: Windmill Generator, Pt.4; Sports Scoreboard, Pt.1; Swimming Pool Lap Counter; Inductance & Q-Factor Meter, Pt.2; Shielded Loop Antenna For AM; Cheap UV EPROM Eraser; Sending Picaxe Data Over 477MHz UHF CB; $10 Lathe & Drill Press Tachometer.

April 2005: Install Your Own In-Car Video (Reversing Monitor); Build A MIDI Theremin, Pt.1; Bass Extender For Hifi Systems; Sports Scoreboard, Pt.2; SMS Controller Add-Ons; A $5 Variable Power Supply.

May 2005: Getting Into Wi-Fi, Pt.1; Build A 45-Second Voice Recorder; Wireless Microphone/Audio Link; MIDI Theremin, Pt.2; Sports Scoreboard, Pt.3; Automatic Stopwatch Timer.

June 2005: Wi-Fi, Pt.2; The Mesmeriser LED Clock; Coolmaster Fridge/Freezer Temperature Controller; Alternative Power Regular; PICAXE Colour Recognition System; AVR200 Single Board Computer, Pt.1.

July 2005: Wi-Fi, Pt.3; Remote-Controlled Automatic Lamp Dimmer; Lead-Acid Battery Zapper; Serial Stepper Motor Controller; Salvaging & Using Thermostats; Unwired Modems & External Antennas.

August 2005: Mudlark A205 Valve Stereo Amplifier, Pt.1; Programmable Flexitimer; Carbon Monoxide Alert; Serial LCD Driver; Enhanced Sports Scoreboard; Salvaging Washing Maching Pressure Switches.

September 2005: Build Your Own Seismograph; Bilge Sniffer For Boats; VoIP Analog Phone Adaptor; Mudlark A205 Valve Stereo Amplifier, Pt.2; PICAXE in Schools, Pt.4.

October 2005: A Look At Google Earth; Dead Simple USB Breakout Box; Studio Series Stereo Preamplifier, Pt.1; Video Reading Aid For Vision Impaired People; Simple Alcohol Level Meter; Ceiling Fan Timer.

November 2005: Good Quality Car Sound On The Cheap; Pt.1; Microbric – Robotics For Everyone; PICAXE In Schools, Pt.5; Studio Series Stereo Headphone Amplifier; Build A MIDI Drum Kit, Pt.1; Serial I/O Controller & Analog Sampler; Delta XL02 Tower Loudspeaker System.

December 2005: Good Quality Car Sound On The Cheap; Pt.2; Building The Ultimate Jukebox, Pt.1; Universal High-Energy Ignition System, Pt.1; Remote LED Annunciator For Queue Control; Build A MIDI Drum Kit, Pt.2; 433MHz Wireless Data Communication.

January 2006: Pocket TENS Unit For Pain Relief; "Little Jim" AM Radio Transmitter; Universal High-Energy Ignition System, Pt.2; Building The Ultimate Jukebox, Pt.2; MIDI Drum Kit, Pt.3; Picaxe-Based 433MHz Wireless Thermometer; A Human-Powered LED Torch.

February 2006: Electric-Powered Model Aircraft, Pt.1; PC-Controlled Burglar Alarm System, Pt.1; Build A Charger For iPods & MP3 Players; Picaxe-Powered Thermostat & Temperature Display; Build A MIDI Drum Kit, Pt.4; Building The Ultimate Jukebox, Pt.3.

March 2006: The Electronic Camera, Pt.1; PC-Controlled Burglar Alarm System, Pt.2; Low-Cost Intercooler Water Spray Controller; AVR ISP SocketBoard; Build A Low-Cost Large Display Anemometer.

April 2006: The Electronic Camera, Pt.2; Studio Series Remote Control Module (For A Stereo Preamplifier); 4-Channel Audio/Video Selector; Universal High-Energy LED Lighting System, Pt.1; Picaxe Goes Wireless, Pt.1 (Using the 2.4GHz XBee Modules).

May 2006: Lead-Acid Battery Zapper & Condition Checker; Universal High-Energy LED Lighting System, Pt.2; Passive Direct Injection (DI) Box For Musicians; Remote Mains Relay Box; Vehicle Voltage Monitor; Picaxe Goes Wireless, Pt.2; Boost Your XBee's Range Using Simple Antennas; Improving The Sound Of Salvaged Loudspeaker Systems.

June 2006: Television – The Elusive Goal, Pt.1; Electric-Powered Model Aircraft, Pt.2; Pocket A/V Test Pattern Generator; Two-Way SPDIF-to-Toslink Digital Audio Converter; Build A 2.4GHz Wireless A/V Link; A High-Current Battery Charger For Almost Nothing.

July 2006: Television – The Elusive Goal, Pt.2; Mini Theremin Mk.2, Pt.1; Programmable Analog On-Off Controller; Studio Series Stereo Preamplifier; PC-Controlled Mains Switch, Mk.2; Stop Those Zaps From Double-Insulated Equipment.

August 2006: Video Projector Survey; Television – The Elusive Goal, Pt.3; Novel Picaxe-Based LED Chaser Clock; Build A Magnetic Cartridge Preamplifier; An Ultrasonic Eavesdropper; Multi-Throttle Control For PC Flight Simulators; Mini Theremin Mk.2, Pt.2.

September 2006: Thomas Alva Edison – Genius, Pt.1; Transferring Your LPs To CDs & MP3s; Turn an Old Xbox Into A $200 Multimedia Player; Picaxe Net Server, Pt.1; Build The Galactic Voice; Aquarium Temperature Alarm; S-Video To Composite Video Converter.

October 2006: Thomas Alva Edison – Genius, Pt.2; Review – The CarChip E/X (Logs All Sorts Of Data); LED Tachometer With Dual Displays, Pt.1; UHF Prescaler For Frequency Counters; Infrared Remote Control Extender; Picaxe Net Server, Pt.2; Easy-To-Build 12V Digital Timer Module; Build A Super Bicycle Light Alternator.

November 2006: Sony Alpha A100 Digital SLR Camera (Review); Build A Radar Speed Gun, Pt.1; Build Your Own Compact Bass Reflex Loudspeakers; Programmable Christmas Star; DC Relay Switch; LED Tachometer With Dual Displays, Pt.2; Picaxe Net Server, Pt.3.

December 2006: Bringing A Dead Cordless Drill Back To Life; Cordless Power Tool Charger Controller; Build A Radar Speed Gun, Pt.2; Heartbeat CPR Training Beeper; Super Speedo Corrector; 12/24V Auxiliary Battery Controller; Picaxe Net Server, Pt.3.

January 2007: Versatile Temperature Switch; Intelligent Car Air-Conditioning Controller; Remote Telltale For Garage Doors; Intelligent 12V Charger For SLA & Lead-Acid Batteries.

February 2007: Remote Volume Control & Preamplifier Module, Pt.1; Simple Variable Boost Control For Turbo Cars; Fuel Cut Defeater For The Boost Control; Low-Cost 50MHz Frequency Meter, Mk.2; Bike Computer To Digital Ammeter Conversion.

March 2007: Programmable Ignition System For Cars, Pt.1; Remote Volume Control & Preamplifier Module, Pt.2; GPS-Based Frequency Reference, Pt.1; Simple Ammeter & Voltmeter.

April 2007: The Proposed Ban On Incandescent Lamps; High-Power Reversible DC Motor Speed Controller; Build A Jacob's Ladder; GPS-Based Frequency Reference, Pt.2; Programmable Ignition System For Cars, Pt.2; Dual PICAXE Infrared Data Communication.

May 2007: 20W Class-A Amplifier Module, Pt.1; Adjustable 1.3-22V Regulated Power Supply; VU/Peak Meter With LCD Bargraphs; Programmable Ignition System For Cars, Pt.3; GPS-Based Frequency Reference Modifications; Throttle Interface For The DC Motor Speed Controller.

June 2007: 20W Class-A Amplifier Module, Pt.2; Knock Detector For The Programmable Ignition; Versatile 4-Input Mixer With Tone Controls; Fun With The New PICAXE 14-M; Frequency-Activated Switch For Cars; Simple Panel Meters Revisited.

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Multiple messages in Voice Recorder

I have built the HK828 Voice Recorder (SILICON CHIP, May 2005) for "Normal Tape Mode" operation (ie, sequential messages). Unfortunately, each recording overwrites the initial one!

I have applied all of the conditions required, as specified in the Honsitik factory data sheet. However, only the last recorded message is ever heard, as if recording was done in the "Auto Rewind Mode". Any suggestions? (D. G., Canberra, ACT).

● It sounds as if though you are trying to record a number of messages, each of which requires virtually all of the chip's memory to record it. That would give the symptoms you describe.

The data sheet for the HK828 chip is quite confusing but we think you may need to configure the chip for "random access" message storage, to record a number of messages.

SMS Controller for beehive monitoring

I want to use the SMS Controller (SILICON CHIP, October & November 2004) to remotely weigh beehives in the bush. However, the Nokia model phones suggested in the kit are now very difficult to obtain, especially the data cables.

Is there an alternative cable and phone that will be easier to obtain than the units named in the kit which are now deemed out of date and what modifications are required to make this work? Please note that I am not an electronics person but I learn fast. (B. S., via email).

● The SMS Controller project was designed to read discrete (digital) inputs and is therefore not suited to a task such as remote weighing.

Having said that, if you only need to be notified when the hives exceed a certain weight, an additional circuit could be designed to interface to one of the controller inputs. Note that this might not be a trivial task – some expertise will be required.

The controller cannot be modified for use with other phones. We note that a number of Internet-based vendors are still offering the phones and data cables for sale.

Another option might be a commercial SMS Controller with a built-in GSM module. Here's an example: **www.mgram.com.au/product_info.php?products_id=1770**

Lift Mechanism For An LCD Screen

I am interested in making a lift cart so that the LCD screen of my computer can be raised and lowered out of a cupboard in our lounge room. The cupboard also doubles as a computer desk.

I read your response to a recent question about motorised curtain openers and was wondering if this could be used in my situation? The only thing I can see not working is once the power is off – ie, the monitor has reached the top – the weight of the screen will lower it again and so it would not stay in position.

Could a stepper motor and controller be utilised and if so, is there a way of adjusting the controller manually instead of through the PC? (M. P., Bellarine, Vic).

● The simplest approach to this problem may be to adapt an electric window mechanism from a car. This should have no trouble lifting the load and will require a minimum of electronics. It should also lock in position at the top of the lift.

Oatley Electronics currently have window winder motors in stock but not the complete mechanism. You would probably need to get that from a wrecker.

Remote control of welding current

I had a brainstorm to use the Remote Volume Control kit to control amperage on a TIG welder. All went well until I struck an arc!

After 20-odd years welding, maybe I should have known there was infrared light in a welding arc! The unit works brilliantly when not exposed to the arc but being infrared-controlled and requiring line of sight to operate renders the kit almost useless.

Is there a simple way I can convert this kit to RF control and still retain the same features or should I just stick to welding? (P. B., via email).

● In essence, you can change any infrared remote control circuit to UHF operation by using the pulse code information to modulate a UHF oscillator instead of an infrared LED. At the receiver end, you need a UHF receiver module and its output can be fed into the infrared decoder circuitry.

To compare the two transmission techniques, have a look at our article entitled "Three Remote Controls" in the February 1996 issue. Oatley Electronics should be able to provide suitable parts.

Parts for the Heat Controller

I am having difficulty obtaining the special semiconductors for your Heat Controller (SILICON CHIP, July 1998).

The hairdryer elements I wish to control total less than 900 watts. Will a MOC3021 non-zero-crossing Triac driver from Dick Smith Electronics be OK in lieu of the MOC3041 zero voltage crossing component specified? Will a 10A BTA10-600B replace the BTA26-600B Triac? Where can I obtain the correct parts if the parts mentioned above will not suffice?

I have built one controller for a commercial hair dryer which works great and now I wish to build another. (D. S., via email).

● The MOC3041 zero crossing Triac

Car Loudspeakers Should Be More Rugged

What is a "car loudspeaker"? Can I please ask you to shed some light on this problem?

I need to replace a couple of tired 100mm speakers mounted in the top of the dashboard of my motor vehicle. In fidelity terms, the application is undemanding. In shopping around, I find a very big difference in the cost of speakers intended for use in cars ($50-$100) and those intended for more general applications ($12-$50).

This begs the question, what is so special about a car loudspeaker? Most have 4-ohm voice coils but is that the only thing that defines them? Can 8-ohm speakers be used in a car system. If so, with what effect? (P. F., Willoughby, NSW).

● While it may be thought that there is little to distinguish car speakers from hifi speakers, we would expect car speakers to be much more rugged and able to withstand the severe heat and vibration in a car.

Their suspension also needs to be rugged enough to cope with the high G forces experienced when doors are slammed and the high pressures experienced when the boot lid is slammed – this would apply particularly to speakers intended for installation on the rear parcel shelf.

Speakers installed so that they face upwards also tend to sag unless they have a strong suspension and the effects of direct sunlight on parcel shelf or dashboard will cause general-purpose drivers to quickly deteriorate.

Typically car speakers are also 4Ω or 2Ω to enable higher power to be delivered to them from typical car amplifiers. Partly because of their rugged suspension, they may also have a relatively high cone resonance and may not be very efficient.

So if you substitute a general purpose or hifi speaker in a car, it may have a short life, unless it is built into its own enclosure rather than installed in doors or on the parcel shelf. Even so, the high temperature and high vibration may also kill it. Having said that, many "car speakers" are over-priced.

driver must be used. It can be obtained from Altronics (Cat. Z1644) **www.altronics.com.au** or Farnell (see below).

The Triac specified is a TOP3 insulated tab type and the BTA10 type is definitely not suitable. A BTA41-600BRG (TOP-3 isolated tab) Triac is available from Farnell. Contact **www.farnellinone.com.au** or phone 1300 361 005. The catalog number is 105-7288. The MOC3042 (Cat. 102-1368) can be used instead of the MOC3041.

Jacobs Ladder spark gap

In your article on the Jacob's Ladder project (SILICON CHIP, April 2007) you say the experimenter must provide a temporary spark gap, otherwise the coil may be damaged by an internal discharge. I wonder if you might elaborate on this a bit; ie, how likely is it? If no damage occurs, where does the energy go?

Secondly, could you explain what happens with a short circuit on the secondary? (R. G., Mangoplah, NSW).

● Strictly speaking, it is not a problem with the specified coil since we have now done a lot of tests where the spark jumped between the two high-voltage terminals without problems. It is a very rugged coil.

However, with many ignition coils, particularly the older varieties, if there is no defined external spark gap to limit the secondary voltage, you can get the discharge inside the coil and if this happens a few times, it can permanently damage the coil to the extent that it will no longer work.

However, providing a spark gap as suggested in the text is still a good idea because if the coil is not being driven quite hard enough for the spark to jump between the two high voltage terminals, there will be no apparent indication that the cirucit is working (apart from a slight audible crackle from the coil). And if you touched the coil terminals while the circuit was apparently not operating, you would get an almighty belt and you might involuntarily utter a few profanities.

Well, you might not but we certainly would if it happened to us, so put the spark gap in, as suggested. A short cir-

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Troubleshooting A Damaged Amplifier Module

I was wondering if you could help me with a problem I have with the Class-A amplifier (SILICON CHIP, July & August 1998). I previously built two units for a stereo amplifier and the results were absolutely outstanding.

Wanting to bi-amp the mid & treble drivers in my speakers, I built a couple more. However, I made an error when wiring in the speaker protector circuit (April 1997) which resulted in the positive output terminals of the mid & treble amplifiers for each channel being connected together at the relay terminals. This resulted in terrible distortion through the speakers (the crossovers had been removed, as I had installed an active crossover between the preamplifier and power amplifiers).

After I found the error, I removed the tweeter amplifiers and restored the entire circuit back to its original configuration but the distortion remains. I have removed the speaker protector temporarily but to no avail and so I am certain that the problem lies in the Class-A circuits.

Not wanting to replace the entire modules and hoping to have to only replace a few components, could you please suggest what might have been affected in the amplifier circuit to be producing the distortion? (P. S., Lane Cove, NSW).

● If distortion remains it suggests that something in the output stage or the Vbe multiplier has been damaged. You really need to go over the whole module and check voltages and redo the quiescent current setting. Our guess is that one of the driver stage transistors has been damaged.

cuit on the secondary should cause no damage but all the energy stored in the coil will then be dissipated inside the coil and continued operation in this condition may cause overheating.

Driving electrostatic loudspeakers

I would like to know if your new class-A amplifier is stable enough to drive electrostatic speakers such as the Quad ELS 57? It truly is a superb amplifier.

● Our new class-A amplifier has unconditional stability but it is not really a question of stability. There would be two problems, as follows.

First, it does not really have sufficient power to driver the Quad electrostatics unless you have modestly-sized listening room. Second, it is not configured to drive a transformer, which all ELS electrostatic loudspeakers use.

If you particularly wanted to drive the Quad electrostatics, you would need a trimpot in the emitter of the differential input stage so that the residual DC voltage at the output could be adjusted very close to zero (ideally less than ±5mV. Also, you would need reverse-biased power diodes connected across both output transistors, to protect them from spikes produced by the transformer load if it is over-driven.

How to connect to a record turntable

I have to fit a preamp to my record turntable so that I can have audio coming out of my speakers via the amplifier. However, there are no take-off points on my turntable to connect to the preamp.

Is it possible to connect a couple in and how would I go about this? I have an AWA turntable. (J. B. via email).

● Your turntable should have a set of RCA sockets at the back or a lead with a pair of RCA plugs fitted. If not, have a look underneath the turntable to find a small tagstrip near the pivot for the tonearm. This will have the leads from the cartridge terminated to it and you will need to wire a lead using shielded figure-8 cable and a pair of RCA plugs.

You also need to identify the cartridge which may be ceramic or magnetic. If it is magnetic, you can use one of our phono preamplifiers. If it is ceramic you will need to modify the preamplifier along the lines described in the next answer.

Preamplifier for ceramic cartridge

I am currently using the preamp stage of an old amplifier between the output of a crystal stylus and alternatively a cassette deck, feeding signals to a computer sound card in order to copy my old vinyls and tapes to CD. This works OK.

WARNING!

SILICON CHIP magazine regularly describes projects which employ a mains power supply or produce high voltage. All such projects should be considered dangerous or even lethal if not used safely.

Readers are warned that high voltage wiring should be carried out according to the instructions in the articles. When working on these projects use extreme care to ensure that you do not accidentally come into contact with mains AC voltages or high voltage DC. If you are not confident about working with projects employing mains voltages or other high voltages, you are advised not to attempt work on them. Silicon Chip Publications Pty Ltd disclaims any liability for damages should anyone be killed or injured while working on a project or circuit described in any issue of SILICON CHIP magazine. Devices or circuits described in SILICON CHIP may be covered by patents. SILICON CHIP disclaims any liability for the infringement of such patents by the manufacturing or selling of any such equipment. SILICON CHIP also disclaims any liability for projects which are used in such a way as to infringe relevant government regulations and by-laws.

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I thought the Universal Preamplifier (SILICON CHIP, May 1994) might be better, together with a volume control. I used the tape circuit as the input. It works but with considerable distortion.

I then put the volume control before the preamp and with the volume turned right down, it is almost OK but still slightly distorted. It seems I only need a small amount of gain, perhaps about 10. I note this is done by varying R2 & R4. Can you advise? (P. F., via email).

● To run a ceramic (crystal) cartridge, you need to drastically reduce the gain and increase the input shunt capacitance. We suggest increasing the 100pF input capacitor to 3.3nF (3300pF) or more.

To reduce the gain, use the mic version of the preamp but change R4 to 2.2kΩ and R2 to 22kΩ. You may need to fiddle with these to get the right result. The volume control should come after the preamp.

Weather satellite receiver impedance

I built the Weather Satellite Receiver (SILICON CHIP, December 2003) and I am struggling to understand something. The receiver's RF input says 50Ω but the antenna specification and preamplifier appear to be 75Ω. I would have thought that the impedances should match or am I misunderstanding something? (G. W., via email).

● You are not misunderstanding anything. Perhaps we didn't make it quite clear enough. The cable between the RF preamp and the input of the receiver itself should strictly be of 50Ω impedance, even though the connector at the preamp end is nominally of the 75Ω type. But as you're probably aware, the connector at the receiver input is an RCA type, with a nominal impedance of 75Ω ohms (very roughly!).

In reality, the difference in performance between using cables of 50Ω and 75Ω impedance between the preamp and the receiver is likely to be negligible. So unless you need a very long cable (over 50m), it won't really matter which cable impedance you use. SC

Add-on Regulator For 12V Battery Charger

I have a question regarding the "Add-on Regulator for 12V Battery Charger" from "Electronics Australia".

I built the kit and it is working very well but I want to know if it is safe to connect it directly across the battery circuit and therefore also the vehicle control computer.

I have been concerned that the switching action of the regulator might generate spikes that could damage the computer, so to date, I have been disconnecting the battery from the vehicle wiring when charging the battery. It would be much more convenient not to have to do this.

Can you please help? (P. H., Lindfield, NSW).

● In practice, there should be no problems using the Add-on Regulator and a standard battery charger to charge the battery in your car.

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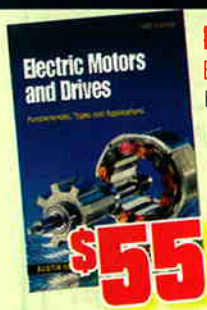

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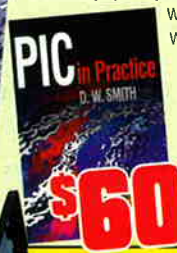

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